SECTION 7

WASTEWATER CHARACTERIZATION

This section presents information on manufacturing process wastewater flow rates and the pollutants generated from iron and steel manufacturing operations. All estimates presented in this section are based on industry information collected for the 1997 calendar year. The selected pollutants of concern (POCs) for each subcategory and segment and the selected model treatment system flow rates for each technology option are also presented. Sections 7.1 and 7.2, respectively, discuss the methodologies for selecting POCs and model flow rates. Sections 7.3 through 7.9 present wastewater sources, pollutants of concern, and wastewater flow rates for each of the seven subcategories.

7.1   Identification of Pollutants of Concern

EPA selected POCs for each subcategory to screen for possible regulation and also to use them as the list of pollutants for which to perform the loading reduction calculations and the environmental assessment analysis. From the list of POCs for each subcategory, EPA determined the list of pollutants to regulate. Section 11 describes the selection of regulated pollutants. The Agency took the following approach in identifying POCs.

EPA used analytical data collected during the sampling episodes conducted at 16 iron and steel facilities as the dataset for the screening (see Section 3). EPA analyzed untreated wastewater samples from each manufacturing process characterized to identify pollutants present in wastewaters from each process. For each manufacturing process analyzed, EPA selected POCs using the following detection criteria:

- The pollutant was detected at greater than or equal to 10 times the minimum level (ML) concentration in at least 10 percent of all untreated process wastewater samples; and

- The mean detected concentration in untreated process wastewater samples was greater than the mean detected concentration in the source water samples.

In addition to the criteria outlined above, the Agency made the following considerations:

- EPA considered three pollutants as POCs for all manufacturing processes, independent of the above criteria: total suspended solids (TSS), oil and grease measured as hexane extractable material (HEM), and total petroleum hydrocarbons measured as silica gel treated hexane extractable material (SGT-HEM). These analytes are present to some degree in nearly

all steel industry process wastewater and are important indicators of overall wastewater treatment system performance.

• EPA did not evaluate pH as a candidate POC, since pH is not expressed in terms of quantity or concentration. However, the pH level is an important wastewater characteristic and an important indicator of wastewater treatment system performance in many applications in the steel industry, so EPA is proposing to regulate pH.

• Except where noted, EPA excluded the following pollutants from consideration as POCs for all manufacturing process divisions because they are either dissolved substances or common elements found in wastewater, and because some of them are not treatable: TSS, calcium, chloride, sodium, total sulfide, and sulfate.

Because the Agency generally considers wastewater from manufacturing processes within a segment of a subcategory to be compatible and co-treatable, EPA generated segment-level POC lists to use in subsequent analyses. See Section 6 for a discussion of subcategorization and segmentation. Below is the rationale for determining how each segment-level POC list was developed for each segmented subcategory:

• Cokemaking Subcategory. EPA selected POCs for the By-Product Segment of this subcategory. EPA did not select POCs for the Non-Recovery Segment, as non-recovery cokemaking operations do not generate process wastewater.

• Ironmaking Subcategory. Because the characteristics of wastewater in this subcategory's two segments are somewhat different, EPA selected two lists of POCs for this subcategory, one for the Blast Furnace Segment and one for the Sintering Segment.

• Integrated Steelmaking Subcategory. Because wastewater from each of the three manufacturing processes that generate process wastewater (basic oxygen furnaces, vacuum degassing, and continuous casting) in this subcategory are commonly co-treated, EPA selected POCs for each manufacturing process, and then compiled the list of POCs for the subcategory from those pollutants that were selected as POCs in at least one of the three manufacturing processes.

• Integrated and Stand-Alone Hot Forming Subcategory. Because the characteristics of wastewater from this subcategory are affected by the type of steel processed, EPA selected two lists of POCs for this subcategory, one for the Carbon and Alloy Steel Segment and one for the Stainless Steel Segment.

- • **Non-Integrated Steelmaking and Hot Forming Subcategory**. For the same reason as stated above, EPA selected two lists of POCs for the Carbon and Alloy Steel Segment and the Stainless Steel Segment. Moreover, because wastewater streams from each of the three manufacturing processes that generate process wastewater (vacuum degassing, continuous casting, and hot forming) within each segment are compatible and are commonly co-treated, the list of POCs for each segment comprises those pollutants that were selected as POCs in at least one of the three manufacturing processes.

- • **Steel Finishing Subcategory**. EPA selected two lists of POCs for the Carbon and Alloy Steel Segment and the Stainless Steel Segment. EPA compiled the lists of POCs for the two segments in the same way as for the Non-Integrated Steelmaking and Hot Forming Subcategory.

- • **Other Operations Subcategory**. EPA selected POCs for the Direct Reduced Ironmaking Segment of this subcategory. EPA did not sample forging operations during the sampling program and, therefore, did not select POCs for the Forging Segment. EPA did not select POCs for the Briquetting Segment, as briquetting operations do not discharge process wastewater.

7.2 **Calculation of Production-Normalized Flow Rates**

EPA's selection of model treatment system flow rates has a large impact on development of the effluent limitations guidelines and standards. This section reviews the Agency's methodology for selecting the process wastewater flow rate for each manufacturing operation that is used in developing the proposed effluent limitations guidelines and standards. These flow rates are expressed as production-normalized flow rates (PNFs) in terms of gallons of water discharged per ton of production (gpt) for all operations except certain wet air pollution control devices associated with steel finishing operations, where the flow rates are expressed in gallons per minute (gpm), since they are independent of production.

Because the Agency considers good water management practices and decreased wastewater discharge volumes to be key components of effective pollution control, it has selected its model discharge flow rates based on the better performing mills within a given subcategory or segment. EPA also considered whether all facilities within any given segment can achieve the selected PNFs. The Agency has concluded that all of the selected model flow rates that are described in the subsequent subsections are both well demonstrated and achievable.

The Agency analyzed industry survey data for each manufacturing unit or process line within the subcategory or segment to determine model treatment system flow rates. EPA used the industry survey data to identify every source of process wastewater generated by a manufacturing operation. With each source of process wastewater identified, the Agency calculated the total process wastewater discharge flow rate for each manufacturing operation.

Table 7-1 provides EPA's estimates for the annual discharge rate by operation and discharge type (direct or indirect) and the number of zero or alternative dischargers for each operation. Most zero or alternative dischargers are non-integrated, stand-alone hot forming, or stand-alone finishing facilities.

To normalize flow rates across the industry and for a range of facility sizes, EPA then calculated PNFs for each manufacturing operation in a given segment. Calculating PNFs for the individual operations allowed EPA to develop a profile of PNFs across a given segment. The Agency analyzed these profiles for trends and similar characteristics to develop a well-demonstrated model flow rate for each segment.

EPA did not include nonprocess wastewater sources in the calculation of PNFs. The largest source of nonprocess wastewater is noncontact cooling water, but other sources include storm water and recovered ground water. Nonprocess wastewaters were not included in the calculation of PNFs because: 1) EPA calculated the amount of wastewater directly generated from manufacturing operations that displayed wastewater characteristics requiring treatment, and 2) nonprocess wastewater differs from process wastewater in that it does not directly contact processed or raw materials as part of the manufacturing operations, and often does not require treatment. EPA recognizes that storm water from iron and steel sites can become contaminated with a variety of pollutants from raw materials and finished products that are stored outdoors, and may require treatment before discharge. However, EPA determined that it was not appropriate to include weather-variable storm water flows in the PNFs.

For those manufacturing operations where high-rate recycle is a principal component of the model treatment technology, the Agency selected PNFs by analyzing recycle system recirculating water rates and blowdown flow rates. EPA selected a model flow rate from the best performing mills exclusive of those systems achieving zero discharge. The Agency justifies this approach because the owner or operator directly controls the volume of the discharge by controlling the process water treatment and recycle system. This is accomplished by managing the amounts of make-up water and storm water entering the system, removing and/or minimizing the potential for nonprocess wastewater entering the system, and by controlling recirculating water chemistry to prevent fouling and scaling, where necessary. EPA also included sufficient costs in the cost models to account for flow rate reductions. To identify the best performing mills, EPA looked at each segment independently to identify discriminating characteristics that influence the amount of wastewater generated and discharged.

For most manufacturing operations where high-rate recycle is not a principal component of the technology options, the Agency chose to use a PNF approximating the median PNF reported by the industry in those subcategories and segments. EPA determined that selecting median flow rates for once-through systems accurately represents well-demonstrated flow rates because 50 percent of the subcategory or segment is able to achieve the model flow rate. However, for a few segments (e.g., carbon and alloy hydrochloric acid pickling - strip and sheet, carbon and alloy sulfuric acid pickling - strip and sheet) where data clearly indicated a well-demonstrated flow rate below the median, the Agency selected a model flow rate less than the

median. For those manufacturing operations where the selected model flow rate is greater than the median, the Agency determined that the costs associated with meeting the median flow rate would preclude certain sites from being able to obtain the model flow rate. EPA looked at each segment independently to identify discriminating characteristics that influence the amount of wastewater generated and discharged. The Agency included sufficient costs in its models to account for flow rate reductions, and, in some cases, transferred flow rates from the 1982 regulation.

The following seven subsections present wastewater sources, pollutants of concern, and wastewater flow rates for each proposed subcategory.

7.3 **Cokemaking Subcategory**

Sources

The proposed Cokemaking Subcategory covers the by-product and non-recovery cokemaking segments. EPA analyzed industry survey responses for 16 stand-alone coke plants and nine coke plants at integrated mills to develop the model PNF; one stand-alone non-recovery coke plant began operations after 1997 but was still used in the flow rate analysis. Three sites are zero discharge sites: two do not generate process wastewater (non-recovery cokemaking sites) and one disposes of its wastewater by a combination of coke quenching and deep-well injection. The Agency evaluated the 23 sites that generate process wastewater to develop a profile of the wastewater generated at cokemaking facilities.

By-product cokemaking operations generate wastewater from a number of sources. The greatest volume of wastewater generated at by-product sites is waste ammonia liquor, which is the condensed combination of coal moisture and volatile compounds released from the coal during the coking process. Nearly all sites reported other sources of wastewater, including the following:

- Coke oven gas desulfurization;

- Crude light oil recovery;

- Ammonia still operation;

- Final gas coolers;

- National emission standards for hazardous air pollutants (NESHAP) controls for benzene;

- Barometric condensers;

- Coke oven gas condensates;

- Equipment cleaning;

- Excess coke quenching water; and

- Wet air pollution control devices used to control emissions from coal charging and coke pushing.

Pollutants of Concern

Based on an analysis of EPA sampling data and industry-provided data from the analytical and production survey (see Section 3), EPA determined that by-product cokemaking wastewater contains O&G, ammonia-N, cyanides, thiocyanates, phenolics, benzene, toluene, xylene, benzo(a)pyrene, and numerous other volatile organic compounds and polynuclear aromatic compounds. From the sampling data, EPA selected 71 POCs for the By-Product Segment of the Cokemaking Subcategory, presented in Table 7-2. EPA included total Kjeldahl nitrogen (TKN), weak acid dissociable (WAD) cyanide, and thiocyanate as POCs because they are widely present in cokemaking wastewater (each was detected at significant concentrations in all 16 untreated cokemaking wastewater samples collected) and are important indicators of biological treatment effectiveness. However, since no method minimum levels (MLs) were specified at the time of this analysis, they could not be evaluated with the POC selection criteria. Even though nitrate/nitrite failed the screening criteria, EPA selected it as a POC because of its importance as an indicator of biological treatment effectiveness.

Wastewater Flow Rates

After identifying the wastewater sources identified by the industry survey respondents, the Agency determined representative flow rates for each of the sources. The total model flow rate for by-product cokemaking was the sum of each of these sources. The waste ammonia liquor, crude light oil recovery, final gas cooler condensate, barometric condenser blowdown, and control water PNFs are unchanged from the model PNFs in the 1982 regulation. Review of the industry survey data determined that the current flow rates are still applicable and achievable. EPA did not consider a flow allowance for coke oven gas condensates when developing the model PNF for the 1982 regulation. However, in the industry survey, 14 sites reported collecting and treating coke oven gas condensates; reported flow rates ranged from less than 1 gpt to approximately 4 gpt. Therefore, the Agency determined that a flow allowance of 3 gpt was appropriate for coke oven gas condensates. EPA decreased the flow allowance for ammonia still steam from 13 gpt in the 1982 regulation to 10 gpt in the proposed regulation, because six of the 11 sites that reported a flow rate for ammonia still steam indicated flow rates below 10 gpt.

EPA proposed that the miscellaneous flow rate be increased from 20 gpt in the 1982 regulation to 25 gpt. This increase accounts for additional wastewater treated at coke plant treatment systems, primarily collected storm water and other miscellaneous waters collected from the site. Many sites have improved their collection of miscellaneous waters since the

promulgation of the 1982 regulation. The Agency believes that collecting and treating these waters prior to discharge is a good operating practice and thus proposes an increased flow allowance for these miscellaneous wastewaters.

Excess coke quenching water is another potential source of wastewater reported in the industry surveys. Water used for coke quenching is typically plant service water or treated coke plant wastewater. The Agency does not advocate the practice of coke quenching with untreated wastewater because of the potential for air pollution and ground water contamination associated with this practice. To the Agency's knowledge, coke quenching with untreated process wastewaters is no longer practiced at any of the coke plants that responded to the industry survey. Standard industry practice is to recycle coke quenching water to extinction; therefore, the Agency did not give an allowance for excess coke quenching water. Similarly, it is also standard industry practice to dispose of wastewater from wet air pollution control (WAPC) systems from coke pushing by coke quenching. The Agency supports this practice because this type of WAPC wastewater does not contain volatile pollutants found in waste ammonia liquor and other untreated wastewaters. Because coke quenching has been designated as a zero discharge operation, EPA gave no additional flow allowance for WAPC wastewater from coke pushing.

EPA also proposes supplemental allowances for those sites that operate wet coke oven gas desulfurization systems or NESHAP control systems that generate process wastewater. Since these operations are not practiced by a large percentage of the industry, the Agency found it inappropriate to use these operations to develop the model by-product cokemaking PNF. However, the Agency does realize that these operations generate process wastewater and has developed additional allowances for those sites that operate wet desulfurization systems or NESHAP control systems. An additional 15 gpt would be allowed for wet desulfurization, while an additional 10 gpt would be allowed for NESHAP controls. Approximately 50 percent of the sites reporting these wastewater sources achieve both of these flow rates; therefore, the Agency has determined that these flow rates are well demonstrated and appropriate for the industry. The proposed regulation also contains provisions that would allow National Pollutant Discharge Elimination System (NPDES) and pretreatment permitting authorities to develop, on a site-specific basis, supplemental mass effluent limitations and standards for wastewater resulting from coke plant ground water remediation systems and air pollution control systems not considered in the proposed rulemaking.

EPA determined that biological wastewater treatment systems used to treat cokemaking wastewaters often use control water for toxicity control. To determine an appropriate flow rate, EPA analyzed control water flow rates from the industry survey and the 1982 development document (Reference 7-1). After comparing these data, the Agency determined that the 50-gpt flow allowance from the 1982 development document was still appropriate because of the number of sites currently using that approximate volume of control water to effectively operate their treatment system. Moreover, one coke plant demonstrating best available technology economically achievable (BAT) treatment is using control water at a rate of approximately 50 gpt to achieve its treatment effectiveness.

The following table presents the model PNFs for each source and the overall by-product cokemaking model PNF.

By-Product Cokemaking Wastewater Flow Rates

Wastewater Source	PNF (gpt)
Waste ammonia liquor	32
Crude light oil recovery	25
Final gas cooler condensate	10
Coke oven gas condensate	3
Barometric condenser blowdown	3
Steam and caustic solution from ammonia still	10
Miscellaneous[a]	25
Total base flow	**108**
Control water (dilution water added to control toxicity prior to biological treatment)	50
Total base flow with control water	**158**

[a]Miscellaneous sources include such flows as equipment cleaning water, storm water, and other wastewater collected and treated from cokemaking or by-product recovery operations.

EPA determined that the selected cokemaking model flow rate is well demonstrated because each of the sites identified as operating a BAT treatment system is able to achieve the model flow rate. The Agency considers these sites to be the best performing in the subcategory and has concluded that the flow rates that they are achieving are obtainable for every site.

Non-recovery cokemaking has been designated as a zero discharge operation because it does not generate process wastewater other than boiler blowdown and process area storm water, which are disposed of by coke quenching.

7.4   Ironmaking Subcategory

Separate discussions are provided below for the Sintering and Blast Furnace Ironmaking Segments of the Ironmaking Subcategory.

7.4.1   Sintering

Sources

The Agency analyzed data from nine sites that provided industry survey information for sintering operations. Sinter plants generate wastewater from air pollution control systems designed to control emissions from the sinter strand wind box and material processing. Seven sites indicated that they used WAPC systems to control air emissions from the sintering process, while two sites used dry air pollution control (DAPC) systems. EPA analyzed wastewater flow rate data for the six sinter plants that provided data for WAPC systems in 1997 (one site operating a WAPC reported being inactive in 1996 and 1997). Currently, only four plants operate a WAPC system (see Section 6). All of the plants operated WAPC systems that recycle wastewater as part of the treatment system; blowdown from the recycle systems is the primary source of wastewater from sintering operations. All of the sinter plants generating process wastewater reported using wet scrubbers to control wind box emissions, and some sites also reported using scrubbers to control emissions at the discharge end of the sinter strand.

Facilities identified other sources of sintering wastewater in the industry surveys, including sinter cooling water, belt sprays, and equipment cleaning water. However, respondents did not provide flow rate data for these sources. The Agency believes the wastewaters would be discharged with the WAPC flow and would not have a significant impact on the model PNF.

Pollutants of Concern

Based on an analysis of EPA sampling data and industry-provided data from the Analytical and Production Survey, EPA determined that sintering wastewater contains the following principal pollutants: TSS, O&G, ammonia-N, cyanide, phenolic compounds, and metals (principally lead and zinc). EPA also found that sintering wastewater contains polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDDs and PCDFs, or dioxins and furans).

EPA selected 65 POCs for the Sintering Segment of the Ironmaking Subcategory, presented in Table 7-3. EPA selected TKN, WAD cyanide, and thiocyanate as POCs because they are widely present in sintering wastewater (each was detected in all 10 untreated sintering wastewater samples collected). However, since no method MLs were specified at the time of this analysis, these pollutants could not be evaluated with the POC selection criteria.

Wastewater Flow Rates

The Agency based its selection of the model PNF on WAPC systems that operated with greater than 95 percent wastewater recycle. The Agency considers plants with this recycle rate representative of the best plants in this segment. Two sites reported operating their WAPC systems at this selected recycle rate and were achieving discharge rates of 0 gpt and 73 gpt, respectively. Using the data from these sites, the Agency selected a model sintering PNF of 75 gpt.

The Agency determined that a 75-gpt model flow rate, coupled with a 95 percent recycle rate, is appropriate for the BAT model treatment systems, because it represents the best demonstrated sintering wastewater treatment system flow rate. The two sites used to develop the model flow rate are representative of other sinter operations in that they include wastewaters from the wind box and other sources. These sites are typical of sinter plants operating WAPC systems, are located in different regions of the country, and are owned by different companies. Furthermore, EPA determined that this model flow rate is achievable by sinter plants that treat sintering wastewaters in a dedicated treatment system or a combined treatment system, as the model sites represent each of these treatment options. EPA also determined that sites not achieving the model PNF will be able to achieve the model flow rate by increasing their wastewater recycle to the selected recycle rate.

The Agency found that sinter plants with dry air pollution controls discharge no process wastewater. Therefore, the Agency has designated sinter plants with dry air pollution controls as zero discharging operations.

7.4.2 Blast Furnace Ironmaking Segment

Sources

Twenty integrated mills indicated in their industry survey responses that they conducted blast furnace ironmaking, with 40 blast furnaces active in 1997. Wastewater from blast furnace ironmaking is primarily generated from wet gas cleaning and cooling systems designed to clean and cool the furnace off-gas prior to its use as a fuel in the blast furnace stoves. The gas cleaning systems use high-energy scrubbers and gas coolers that use water to treat the gas. The blowdown from the gas cleaning systems is the largest source of wastewater from blast furnace ironmaking. Blast furnace gas seals, blast furnace drip legs, equipment cleaning water, and excess slag quenching water comprise the other, relatively minor sources of process wastewater.

Pollutants of Concern

Based on an analysis of EPA sampling data and industry-provided data from the Analytical and Production Survey, EPA determined that the principal pollutants from blast furnaces are TSS, ammonia-N, cyanides, phenolic compounds, and metals (copper, lead, and zinc).

EPA selected 27 POCs for the Blast Furnace Segment of the Ironmaking Subcategory, presented in Table 7-4. EPA selected TKN, WAD cyanide, and thiocyanate as POCs because they are widely present in blast furnace wastewater (each was detected in at least 60 percent of the untreated blast furnace wastewater samples collected). However, since no method MLs were specified at the time of this analysis, these pollutants could not be evaluated with the POC selection criteria.

Wastewater Flow Rates

To analyze the wastewater discharge rates from blast furnace ironmaking, the Agency evaluated each of the wastewater treatment systems in operation. Depending on the site, these systems could potentially treat wastewater from one blast furnace or several blast furnaces. EPA calculated PNFs for each wastewater treatment system identified (24 systems were identified across the industry); therefore, a single site could have multiple PNFs.

Six water systems are achieving zero discharge and four water systems are achieving reduced discharge of blast furnace wastewater by using all or a portion of gas cleaning blowdown for slag quenching. One additional site achieves zero discharge by discharging gas cleaning blowdown to one unlined and one synthetically lined pond where the wastewater infiltrates and evaporates. The Agency does not advocate the practice of using untreated gas cleaning blowdown for slag quenching in unlined slag pits because of ground water contamination and the potential for air pollution associated with this practice. Therefore, the Agency has not selected zero discharge as its model PNF for this segment.

Because slag quenching and infiltration are not endorsed methods of wastewater disposal, EPA used the total amount of wastewater generated from blast furnace operations to develop PNFs. Consequently, EPA used the total gas cleaning blowdown rate from each site, even if it was used for slag quenching, to calculate the PNFs. With this in mind, the Agency evaluated the wastewater recycle at each of the gas cleaning systems. All but two systems recycle gas cleaning wastewater.

EPA based the selection of a blast furnace model flow rate on a recycle rate of 98 percent. Analysis of the data the Agency considers representative of the best plants in this segment showed eight systems recycling 98 percent or more of process wastewater. Each of these systems achieved a discharge rate of 25 gpt or less. The flow rate data for these systems are shown below.

Water System	Number of Furnaces	PNF (gpt)
A	3	4
B	3	6
C	1	6
D	2	10
E	2	17
F	2	23
G	2	24
H	2	25

The Agency determined that these sites were representative of this segment because they include furnaces of various production capacities, are located in different geographic

locations, and are owned by different companies. Additionally, these sites demonstrate that water systems with a single or multiple blast furnaces can achieve the selected model flow rate. EPA also has concluded that operating blast furnace wastewater treatment system with a 98 percent recycle rate is representative of BAT treatment.

7.5   Integrated Steelmaking Subcategory

The Agency did not find any reason to further segment the Integrated Steelmaking Subcategory. However, EPA identified several manufacturing process divisions within the subcategory. This subsection provides separate discussions for basic oxygen furnace (BOF) steelmaking, ladle metallurgy, vacuum degassing, and continuous casting.

7.5.1   Basic Oxygen Furnace (BOF) Steelmaking

Sources

Twenty integrated sites and one non-integrated site indicated in their survey responses that they conducted BOF steelmaking operations; 24 BOF shops were identified as active in 1997. The primary source of wastewater from BOF steelmaking is air pollution control systems designed to treat furnace off-gases prior to release into the atmosphere. Each active BOF shop uses one of three types of WAPC systems: semi-wet, wet-open combustion, or wet-suppressed combustion. These WAPC systems operate differently. Semi-wet systems apply water to the furnace off-gases to condition the off-gases prior to treatment in an electrostatic precipitator (ESP). A wet-suppressed system is a high-energy wet scrubbing system that limits excess air entering the furnace mouth, minimizing carbon monoxide combustion and thus minimizing the volume of gas requiring treatment. A wet-open system is a gas cleaning system that admits excess air to allow the combustion of carbon monoxide prior to high-energy scrubbing. EPA separated and analyzed the flow rate data for BOF steelmaking based on the type of WAPC system used at the BOF shop because of differences in water application rates, discharge rates, and industry-demonstrated recycle rates. Other wastewater sources include slag quenching water, hood cooling water losses, cooling tower blowdown, and equipment cleaning water.

Pollutants of Concern

Based on an analysis of EPA sampling data and industry-provided data from the Analytical and Production Survey, EPA determined that the principal pollutants from BOFs are TSS and metals (lead and zinc). EPA selected 28 POCs for BOF steelmaking, presented in Table 7-5.

Wastewater Flow Rates

During the analysis, EPA identified eight BOF shops operating semi-wet air pollution control systems. Two sites reported zero discharge of process wastewater, while one site reported a discharge of 1 gpt. One other site reported a discharge of less than 10 gpt. Sites achieve zero or relatively low discharges from their semi-wet systems by balancing the applied water with water that evaporates in the conditioning process. Although the 1982 regulation designates semi-wet air pollution control as zero discharge, currently not all of the sites are able to achieve this discharge status because of safety considerations. Some sites operate their semi-wet systems with excess water, which is subsequently discharged, to flush the air pollution control ductwork and prevent the buildup of debris within the ductwork. If this wet debris accumulates, it has the potential to fall back into the BOF, causing explosions and process upsets. The Agency recognizes the benefit of using excess water in these systems and has selected a semi-wet air pollution control model PNF of 10 gpt. The Agency justifies the increased allowance in this case because of the safety and manufacturing considerations impacted by the operation of the air pollution control system. The Agency determined that all sites can achieve this proposed model flow rate.

EPA also identified seven BOF shops operating wet-suppressed combustion air pollution control systems. All of the shops operate their treatment systems with wastewater recycle. The Agency based the model flow rate selection on those BOF shops that operate recycle systems with 97.5 percent recycle or more; EPA considers these shops to be the best performing for this manufacturing operation. After analyzing the data from these shops, the Agency selected a wet-suppressed combustion air pollution control model PNF of 20 gpt. Three shops operating with this recycle rate report flow rates below or slightly above the selected model flow rate. Two shops reported discharge rates of 17 gpt and 22 gpt; one shop achieved a discharge rate of 14 gpt by using carbon dioxide injection in the high-rate recycle system. Carbon dioxide injection allows carbonates to precipitate in the treatment system clarifiers (in effect water softening), thus minimizing the need for blowdown from the system. The BOF shops used to select the model flow rate are typical of all wet-suppressed shops: they generate wastewater from the WAPC system and other miscellaneous sources, they are located in different geographic regions, and they are owned by different companies. EPA determined that shops operating with 97.5 percent recycle and 20-gpt flow rates are representative of BAT operations. The model flow rate is also consistent with the proposed model treatment for wet-suppressed air pollution control systems that utilizes carbon dioxide injection as part of the treatment process.

EPA identified eight BOF shops operating wet-open combustion air pollution control systems. All of the shops operate their treatment systems with wastewater recycle. One shop is able to achieve zero discharge of process wastewater by using carbon dioxide injection, which eliminates the need for system blowdown. As with wet-suppressed systems, the Agency has selected a model PNF of 20 gpt for wet-open combustion air pollution control, based on the use of carbon dioxide injection. The Agency concluded that all sites with proper wastewater recycle and carbon dioxide injection can achieve the proposed model flow. EPA determined that the one wet-open shop currently achieving the model flow rate is representative of all of the wet-

open shops in the United States for the same reasons provided above for wet-suppressed shops. The only difference between this shop and the others is its use of carbon dioxide in the treatment system. Furthermore, the Agency did not propose zero discharge of process wastewaters for wet-open systems because the cost was prohibitive, and EPA did not conclude that zero flow could be achieved by all wet-open combustion sites.

7.5.2 Ladle Metallurgy

The Agency found that, other than for vacuum degassing, no process wastewater is generated or discharged in ladle metallurgy operations. Therefore, the Agency has designated ladle metallurgy as a zero discharge operation.

7.5.3 Vacuum Degassing

Sources

Thirteen integrated sites indicated in their industry survey responses that they conducted vacuum degassing operations in 1997. Wastewater is generated in vacuum degassing operations from vacuum systems (e.g., barometric condensers, steam ejectors) that are used to refine the molten steel. These systems use water to create the vacuum necessary to draw the molten steel from the ladle to remove the impurities; the water becomes contaminated with dissolved off-gases from the steel. No other sources of wastewater were reported.

Pollutants of Concern

Based on an analysis of EPA sampling data and industry-provided data from the Analytical and Production Survey, EPA determined that the principal pollutants from vacuum degassing are TSS and metals (lead and zinc), which volatilize from the steel. EPA selected 15 POCs for vacuum degassing, presented in Table 7-5.

Wastewater Flow Rates

EPA calculated PNFs for 12 integrated sites that provided flow rate information. All of the sites operate wastewater treatment systems with wastewater recycle. After analyzing the data, the Agency based the selection of a model flow rate on recycle systems with 99 percent recycle or greater and selected a model vacuum degassing PNF of 15 gpt. EPA considers sites operating with this recycle rate to be the best performing for this manufacturing operation. Four sites operating with the selected recycle rate reported flow rates less than 15 gpt. The Agency concludes that the selected flow rate is well demonstrated because the better performing sites in the segment are able to achieve it and is achievable by those sites currently discharging at a rate greater than the model PNF.

7.5.4   Continuous Casting

Sources

Twenty integrated sites indicated in their industry survey responses that they conducted continuous casting operations; EPA identified 30 continuous casters at integrated mills that were active in 1997. The largest amount of wastewater is generated in continuous casting from the contact spray cooling of the steel product as it passes through the molds and from flume flushing for the removal of scale. The only other source of process wastewater identified in industry survey responses was equipment cleaning water.

The Agency did not include nonprocess wastewater sources in determining the model PNF, as discussed in Section 7.2. Nonprocess wastewater sources often treated with process wastewater include low-volume losses from closed caster mold and machine cooling water systems.

Pollutants of Concern

Based on an analysis of EPA sampling data and industry-provided data from the Analytical and Production Survey, EPA determined that the principal pollutants from continuous casting are TSS, O&G, and low levels of particulate metals. EPA selected 13 POCs for continuous casting, presented in Table 7-5. Although EPA found lead at relatively low concentrations in sampled continuous casting wastewater, the Agency considers lead a POC for this operation because industry-supplied effluent data indicate that lead was detected in 129 of the 262 samples (49 percent) from integrated continuous casting operations.

Wastewater Flow Rates

During the analysis, the Agency identified that six of the 20 sites operate combined wastewater treatment and/or recycle systems for vacuum degassing, continuous casting, and/or hot forming operations. The common characteristics of the process wastewater from each of these operations allows the sites to commingle and treat the wastewater simultaneously. When determining the PNF for a particular manufacturing operation that shares a combined treatment and/or recycle system with one or more other manufacturing operations, the Agency developed a PNF based on the percentage of wastewater entering the treatment and/or recycle system from each operation.

EPA calculated PNFs for 29 casters for which flow rate data were provided. The Agency selected the model flow rate based on six continuous casters operating with 97 percent recycle or greater; EPA considers these casters to be the best performing for this manufacturing operation. Based on the performance of these casters, EPA selected a model PNF of 20 gpt for continuous casting at integrated sites. The flow rate data for these casters are provided below.

Continuous Caster	Recycle Rate (%)	PNF (gpt)
A	98.7	14
B	99.2	14
C	97.2	17
D	97.5	20
E	98.1	20
F	98.3	20

EPA concluded that these continuous casters are typical of all the casters in the United States because they all generate wastewater from contact cooling and flume flushing, they are located in different geographic regions, and they are owned by different companies.

7.6   Integrated and Stand-Alone Hot Forming Subcategory

Sources

Fifty-seven integrated and stand-alone sites indicated in their industry survey responses that they conducted hot forming operations; EPA identified 71 hot forming operations at integrated and stand-alone mills that were active in 1997. The Agency was unable to analyze data from three processes due to incomplete industry survey responses.

The Agency identified spray water, used for cooling and descaling of the steel during the hot forming process, as the primary wastewater source. For the purposes of this subcategory, EPA uses spray water as a generic term because there are many different sources of spray water within a hot forming mill. Spray water includes the following: high-pressure descaling sprays, roll and/or roll table spray cooling, die spray cooling, scarfer emissions control, hot shear spray cooling, flume flushing, low-pressure/laminar flow cooling, and product cooling on runout tables. Other sources of wastewater included in the development of the model PNFs were roll shop wastewater, wastewater collected in basement sumps, scarfer water, and equipment cleaning water.

The Agency did not include nonprocess wastewater sources in determining the model PNF, as discussed in Section 7.2. Nonprocess wastewater from hot forming operations often treated with process wastewater includes noncontact cooling water from reheat furnaces.

Pollutants of Concern

Based on an analysis of EPA sampling data and industry-provided data from the Analytical and Production Survey, EPA determined that the principal pollutants from carbon steel integrated and stand-alone hot forming facilities are TSS, O&G, and particulate metals. EPA

selected 11 POCs for the Carbon and Alloy Steel Segment of the Integrated and Stand-Alone Hot Forming Subcategory, presented in Table 7-6. Although EPA found lead at relatively low concentrations in sampled hot forming wastewater, the Agency considers lead a POC for this segment because industry-supplied effluent data indicate that lead was detected in 246 of the 331 samples (74 percent) from integrated and stand-alone hot forming operations.

Based on an analysis of industry-provided data from the Analytical and Production Survey, EPA determined that the principal pollutants from stainless steel integrated and stand-alone hot forming facilities are TSS, O&G, and low levels of particulate metals. EPA did not sample any stainless steel integrated or stand-alone hot forming facilities. However, EPA did sample stainless steel non-integrated hot forming operations. Therefore, EPA chose the same POCs selected for the hot forming manufacturing operation of the Stainless Steel Segment of the Non-Integrated Steelmaking and Hot Forming Subcategory for the Stainless Steel Segment of the Integrated and Stand-Alone Hot Forming Subcategory, since the hot forming processes performed and type of steel formed are identical. Fifteen POCs were selected for each of these manufacturing operations, presented in Table 7-7.

Wastewater Flow Rates

During the analysis, the Agency determined that 12 of the 57 sites operate combined wastewater treatment and/or recycle systems for their hot forming operations. When determining the PNF for a particular manufacturing operation that shares a combined treatment and/or recycle system with one or more other manufacturing operations, the Agency developed a PNF based on the percentage of wastewater entering the treatment and/or recycle system from each operation.

EPA selected the model flow rate based on wastewater treatment systems operating with 96 percent recycle. The Agency determined that systems operating with this level of recycle were the best performing mills in the subcategory. EPA selected 100 gpt as the model PNF for integrated and stand-alone hot forming. Twenty-one of the 68 operations reported PNFs less than or equal to 100 gpt, including seven operations that reported zero discharge. All of the operations currently meeting the model PNF operate high-rate recycle systems with recycle rates of at least 95 percent. The mills used to develop the model flow rate are representative of integrated and stand-alone hot forming mills across the industry: they generate wastewater from a variety of sources, including contact water, rolls shops, and basement sumps; they hot form a range of products (e.g., strip, plate, pipe, tube, bar); and they are located in different geographic locations. For those operations with recycle systems that are not achieving the model flow rate, the Agency included sufficient costs to upgrade all of the systems to achieve this rate. For those operations with once-through treatment systems, the Agency included sufficient costs to install and operate high-rate recycle systems that would be able to achieve the model flow rate.

The Agency did not select zero discharge as the model PNF for integrated and stand-alone hot forming sites due to the costs. The Agency determined that the capital costs

involved with retrofitting existing recycle systems to operate at a 100 percent recycle rate would be cost-prohibitive.

7.7   Non-Integrated Steelmaking and Hot Forming Subcategory

The Agency designated Carbon and Alloy Steel and Stainless Steel Segments for the Non-Integrated Steelmaking and Hot Forming Subcategory because of differences in pollutants present in the wastewater. However, EPA also identified several manufacturing process divisions for both segments. Below are separate discussions for electric arc furnace (EAF) steelmaking, ladle metallurgy, vacuum degassing, continuous casting, and hot forming.

7.7.1   Electric Arc Furnace (EAF) Steelmaking

The Agency evaluated data from 69 facilities that indicated in their industry survey response that they performed non-integrated steelmaking. The analysis included a total of 76 EAF shops and 132 EAFs. All EAFs in the United States are equipped with dry or semi-wet air pollution controls, and none discharge process wastewater. One EAF shop has a wet scrubber system that functions as a backup. Accordingly, the Agency is proposing to designate all EAFs as zero discharge operations.

7.7.2   Ladle Metallurgy

The Agency found that no ladle metallurgy operations other than vacuum degassing generate or discharge process wastewater. Therefore, the Agency has designated ladle metallurgy as a zero discharge operation.

7.7.3   Vacuum Degassing

Sources

The Agency evaluated data from the 22 non-integrated sites that indicated in their industry survey response that they performed vacuum degassing. Because some plants operate more than one vacuum degassing operation, the total number of processes evaluated was 30. The Agency was unable to analyze data from five operations due to incomplete survey responses.

The primary source of wastewater from vacuum degassing operations is blowdown from the vacuum system. Other sources of wastewater reported include boiler blowdown and WAPC wastewater.

Pollutants of Concern

From industry-provided data from the Analytical and Production Survey, EPA determined that the principal pollutants for vacuum degassing operations are TSS and metals. EPA did not perform a POC analysis for this segment because the Agency did not sample non-

integrated vacuum degassing operations during its sampling program. However, based on process chemistry and the steel material processed, EPA determined that it is unlikely that wastewater associated with this operation would contain pollutants not already selected as POCs in the other manufacturing processes in the Non-Integrated Steelmaking and Hot Forming Subcategory.

Wastewater Flow Rates

During the analysis, the Agency determined that 15 of the 22 sites operate recycle systems for their vacuum degassing operations. Seven of the 15 sites operate combined wastewater treatment and/or recycle systems. When determining the PNF for a particular vacuum degassing operation whose wastewater treatment and/or recycle system is combined with others systems within the plant, the Agency developed a vacuum degassing PNF based on the relative percentage of process wastewater conveyed to the treatment or recycle system from vacuum degassing operations. EPA assigned vacuum degassing operations that discharge process wastewater to evaporation ponds a PNF of zero. The Agency designated sites that attained zero discharge by using process wastewater as makeup water for other processes zero dischargers, but used the volume of blowdown water from the these operations in determining the model flow rate.

EPA selected 10 gpt as the model PNF for non-integrated vacuum degassing operations. Ten of the 30 vacuum degassing operations reported PNFs equal to or less than 10 gpt, including two operations that reported zero discharge. Of the 10 operations currently operating with a PNF of less than or equal to 10, five have once-through systems, while five have recycle systems. All of the recycle systems currently achieving the model PNF have recycle rates of at least 99.5 percent. The Agency concluded that 10 gpt is a flow rate that well-operated high-rate recycle vacuum degassing systems can achieve.

The Agency did not select zero discharge as the model PNF for non-integrated vacuum degassing operations because of the feasibility of achieving zero discharge on an industry-wide basis. Three of five operations report attaining zero discharge through either evaporation or discharge to another process. The Agency concluded natural evaporation or discharge to another process are not viable treatment options at all facilities. The Agency also does not feel that contract hauling of wastewater from non-integrated operations is a cost-effective option, due to the potentially large volumes of wastewater generated by these operations. Finally, the Agency does not believe it is feasible for all existing non-integrated mills to manage process area storm water such that they can continuously achieve zero discharge.

7.7.4 Continuous Casting

Sources

The Agency analyzed data from the 59 non-integrated sites that indicated in their industry survey responses that they performed continuous casting operations. Because some sites

operate more than one caster, the total number of operations analyzed was 76. The Agency was unable to analyze data from one continuous casting operation due to an incomplete industry survey response.

During the analysis, the Agency identified spray water, used to cool and descale the steel during the casting process, as the primary wastewater source from casting operations. The only other source of process wastewater identified in industry survey responses and included in the development of the model PNF was equipment cleaning water.

The Agency did not include nonprocess wastewater sources in determining the model PNF, as discussed in Section 7.2. Nonprocess wastewater sources treated with process wastewater include low volume losses from closed caster mold and machine cooling water systems.

Pollutants of Concern

From an analysis of EPA sampling data and industry-provided data from the Analytical and Production Survey, EPA determined that the principal pollutants in continuous casting wastewater are TSS, metals, and O&G. EPA selected eight POCs for the Carbon and Alloy Steel Continuous Casting segment of the Non-Integrated Steelmaking and Hot Forming Subcategory, presented in Table 7-8. EPA also selected 21 POCs for the Stainless Steel Continuous Casting segment of the Non-Integrated Steelmaking and Hot Forming Subcategory, presented in Table 7-9. EPA selected lead and zinc as POCs for continuous casting operations for both segments because both pollutants are regulated under the 1982 regulation (no distinction was made between steel type in the 1982 regulation), and data collected in support of the 1982 regulation indicated that these pollutants were present in wastewater discharged from continuous casting operations. Although EPA did not detect lead, and only detected zinc at relatively low concentrations, in the limited sampling data collected from continuous casting wastewater, the Agency considers lead and zinc POCs for the following reason: industry-supplied data indicate that, in effluent samples submitted from carbon and alloy steel non-integrated continuous casting operations, lead was detected in 65 of the 70 samples (93 percent) and zinc was detected in 69 of the 70 samples (99 percent), and, in samples submitted from stainless steel operations, lead was detected in 12 of the 15 samples (80 percent) and zinc was detected in 14 of the 15 samples (93 percent).

Wastewater Flow Rates

During the analysis, the Agency determined that 22 sites operate combined wastewater treatment and/or recycle systems for vacuum degassing, continuous casting, and/or hot forming operations. The common characteristics of the process wastewater from these three operations allows facilities to commingle and treat these wastewaters simultaneously. When determining the PNF for a particular operation associated with a combined treatment and/or recycle system, the Agency developed a PNF based on the percentage of wastewater entering the treatment and/or recycle system from each operation.

EPA selected 10 gpt as the model PNF for non-integrated continuous casting. Twenty-eight of the 76 non-integrated continuous casting operations reported PNFs equal to or less than 10 gpt. The Agency identified 16 caster water systems that operated without wastewater discharge. An additional nine sites discharged from their caster water system, but used the discharge as makeup water for other processes. EPA designated sites that reported having no process wastewater discharge from their entire site as having no discharge from their continuous caster(s). EPA considers 10 gpt to be well demonstrated not only because the better performing non-integrated continuous casters are demonstrating this flow rate, but also because of the large percentage (37 percent) of the total casters achieving this flow rate.

The Agency did not select zero discharge as the model PNF for non-integrated continuous casting operations for the same reasons cited in Section 7.3.3 for vacuum degassing.

7.7.5 Hot Forming

Sources

The Agency analyzed data from the 64 non-integrated sites that indicated in their industry survey response that they performed hot forming. Because some plants operate more than one hot forming operation, the total number of operations analyzed was 96. The Agency was unable to analyze data from two operations due to incomplete survey responses.

During the analysis, the Agency identified spray water used to cool and descale the steel during the hot forming process as the primary source of wastewater. For the purposes of this manufacturing operation, spray water is a generic term that includes many different sources of spray water within a hot forming mill. Spray water includes the following: high-pressure descaling sprays, roll and/or roll table spray cooling, die spray cooling, scarfer emissions control, hot shear spray cooling, flume flushing, low-pressure/laminar flow cooling, and product cooling on runout tables. Other sources of wastewater included in the development of the model PNFs were blowdown from roll shop wastewater, wastewater collected in basement sumps, scarfer water, and equipment cleaning and wash down water.

The Agency did not include nonprocess wastewater sources in determining the model PNF, as discussed in Section 7.2. Nonprocess wastewater from hot forming operations that is treated with process wastewater includes noncontact cooling water from reheat furnaces, which is sometimes included in the process water recycle loop or recycled separately with a blowdown to the process water loop.

Pollutants of Concern

From an analysis of EPA sampling data and industry-provided data from the Analytical and Production Survey, EPA determined that the principal pollutants for hot forming mills are TSS, metals, and O&G. EPA selected eight POCs for carbon and alloy steel hot forming operations in the Non-Integrated Steelmaking and Hot Forming Subcategory, presented in Table

7-8. The Agency considers lead and zinc POCs because, even though EPA did not detect lead and detected zinc at relatively low concentrations in the limited sampling data, industry-supplied effluent data indicate that lead was detected in 17 of the 23 samples (74 percent) and zinc was detected in 22 of the 23 samples (96 percent) from carbon and steel non-integrated hot forming operations. EPA selected 15 POCs for stainless steel hot forming operations in the Non-Integrated Steelmaking and Hot Forming Subcategory, presented in Table 7-9.

Wastewater Flow Rates

During the analysis, the Agency identified 41 sites that operate combined wastewater treatment and/or recycle systems for vacuum degassing, continuous casting, and/or hot forming operations. The common characteristics of the process wastewater from these three operations allows facilities to commingle and treat the wastewater simultaneously. When determining the PNF for a particular hot forming operation associated with a combined treatment and/or recycle system, the Agency developed a PNF based on the percentage of wastewater entering the treatment and/or recycle system from the hot forming operation.

EPA selected 50 gpt as the model PNF for non-integrated hot forming mills. Forty-two of the 94 non-integrated hot forming operations reported PNFs equal to or less than 50 gpt. During the analysis, the Agency identified eight operations that operate without discharging wastewater. An additional 16 sites listed discharges from their hot forming water system, but used the discharge as makeup water for other processes or allowed the excess wastewater to evaporate. EPA used the volume of blowdown water from the these hot forming operations in determining the model flow rate. EPA designated sites that reported no process wastewater discharge from their entire site as having no discharge from their hot forming mill(s). EPA considers 50 gpt to be well demonstrated not only because the better performing non-integrated hot forming mills are demonstrating this flow rate, but also because of the large percentage (45 percent) of the total hot forming mills achieving this flow rate.

The Agency did not select zero discharge as the model PNF for non-integrated hot forming mills for the same reasons cited in Section 7.7.3 for vacuum degassing.

7.8   Steel Finishing Subcategory

The Agency established the Carbon and Alloy Steel and Stainless Steel Segments for the Steel Finishing Subcategory because of differences in pollutants present in the wastewater. EPA also identified several manufacturing process divisions between the segments. Below are separate discussions for acid pickling, cold forming, alkaline cleaning, stand-alone continuous annealing, hot coating, and electroplating.

7.8.1   Acid Pickling

Sources

The Agency analyzed data from the 61 sites (integrated, non-integrated, and stand-alone) that indicated in their industry survey responses that they performed acid pickling. Because some plants operate more than one acid pickling line, the number of process lines analyzed was 130. The Agency was unable to analyze data from three lines due to incomplete industry survey responses.

For the proposed rulemaking, EPA defined acid pickling lines to include alkaline cleaning and salt bath and electrolytic sodium sulfate (ESS) descaling operations that occur on the line that includes acid pickling. In a small number of instances, continuous annealing operations with an associated water quench take place on acid pickling lines. In these instances, EPA included discharge from the annealing rinse as a wastewater source from acid pickling lines. The Agency also evaluated acid regeneration operations to determine the volume of wastewater generated and discharged during these operations.

During the analysis, the Agency identified three major sources of wastewater from acid pickling lines. The first is rinse water used to clean the acid solution from the steel. Rinse water comprises the largest volume of wastewater from acid pickling lines to wastewater treatment operations. The second is spent pickle liquor, a solution composed primarily of acid that is no longer an effective pickling agent. The third major source of wastewater is generated by the WAPC devices located above the pickling tanks. Other minor sources of wastewater included in the development of model PNFs were process wastewater from other operations (e.g., salt bath descaling) on the acid pickling lines (spent process baths and rinses); raw material handling, preparation, and storage; tank clean-outs; and equipment cleaning water. Except for blowdown from surface cleaning tanks, these wastewater sources are noncontinuous sources of wastewater that minimally contribute to the total wastewater flow.

Pollutants of Concern

Based on an analysis of EPA sampling data and industry-provided data from the Analytical and Production Survey, EPA determined that the principal pollutants from carbon and alloy steel acid pickling are TSS, lead, and zinc. EPA selected 19 POCs for acid pickling operations in the Carbon and Alloy Steel Segment of the Steel Finishing Subcategory, presented in Table 7-10. EPA selected sulfate as a POC because it is present in sulfuric acid pickling wastewater, which the Agency did not sample.

Using the same analysis, EPA also determined that the principal pollutants from stainless steel acid pickling, ESS descaling, and salt bath descaling operations are TSS, chromium, hexavalent chromium, and nickel. EPA selected 30 POCs for stainless steel acid pickling and descaling operations in the Stainless Steel Segment of the Steel Finishing Subcategory (as selected in at least one of the three pickling or descaling operations listed), presented in Table 7-11. EPA

selected total cyanide as a POC because it can be present in reducing salt bath descaling wastewater, which the Agency did not sample.

Wastewater Flow Rates

When responding to the industry survey, sites had the option of indicating several different discharge destinations for process wastewater. These destinations included the following: on-site regeneration and reuse, discharge to another process or rinse, discharge to treatment, discharge without treatment to publicly owned treatment works (POTWs), discharge to privately owned treatment works (PrOTWs), recycle and reuse, and several zero discharge methods including contract hauling. If a discharge was listed as recycle and reuse, discharge to another process or rinse, or zero discharge or alternative disposal method, such as contract hauling, EPA did not use the discharge in developing the model PNF. Several sites often responded that discharges were split between discharge to treatment and zero discharge methods of disposal such as contract hauling, but did not provide the portion of flow going to each. In these cases, EPA accounted for all of the flow in model PNF development.

The Agency analyzed data from 219 WAPC devices that were reported as being operated on acid pickling lines. After reviewing the 1997 industry survey data and comparing it to the data used to develop the 1982 rule, the Agency determined that the model flow rate of 15 gpm in the 1982 rule is still applicable.

The following tables list the model PNFs for carbon and alloy and stainless steel pickling operations. The Agency did not identify any sites that performed plate pickling operations on carbon and alloy steels. Consequently, the Agency transferred the model plate pickling flow rate from the Stainless Steel Segment to the carbon and alloy steel hydrochloric and sulfuric acid plate pickling manufacturing operations. Similarly, the Agency did not identify any sites that performed pipe and tube pickling operations on stainless steels, and, transferred the model specialty steel pipe and tube flow rate from the 1982 development document.

Carbon and Alloy Steel Hydrochloric Acid Pickling Model Flow Rates

Carbon and Alloy Hydrochloric Acid Pickling	Model PNF (gpt)	Operations Currently Operating at or Below the Model PNF	Number of Operations Analyzed
Strip, sheet	50	18	48
Bar, billet, rod, coil	490[a]	1	1
Pipe, tube	1,020[a]	2	3
Plate	35[b]	N/A	0
Fume scrubber (gal/min)	15[a]	8	14

[a]Value transferred from the 1982 development document.
[b]Value transferred from Stainless Steel Segment.

Carbon and Alloy Steel Sulfuric Acid Pickling Model Flow Rates

Carbon and Alloy Sulfuric Acid Pickling	Model PNF (gpt)	Operations Currently Operating at or Below the Model PNF	Number of Operations Analyzed
Strip, sheet	230	4	10
Bar, billet, rod, coil	280[a]	2	7
Pipe, tube	500[a]	1	1
Plate	35[b]	N/A	0
Fume scrubber (gal/min)	15[a]	34	60

[a]Value transferred from the 1982 development document.
[b]Value transferred from Stainless Steel Segment.

Stainless Steel Pickling Model Flow Rates

Stainless Steel Acid Pickling	Model PNF (gpt)	Operations Currently Operating at or Below the Model PNF	Number of Operations Analyzed
Strip, sheet	700	19	50
Bar, billet, rod, coil	230[a]	1	2
Pipe, tube	770[a]	0	0
Plate	35	3	3
Fume scrubber (gal/min)	15[a]	36	54

[a]Value transferred from 1982 development document.

EPA selected a model flow rate of 50 gpt for hydrochloric acid pickling of strip or sheet because 18 of the 48 process lines were demonstrating this model flow rate. The Agency selected a model flow rate below the median value of 79 gpt for hydrochloric acid pickling of strip and sheet, because the better performing mills were achieving this discharge rate. EPA selected 230 gpt as the model flow rate for sulfuric acid pickling of strip and sheet instead of the median PNF of 265 gpt. The Agency concluded that the selected flow rate roughly approximating, but slightly lower than, the median PNF is well demonstrated and achievable for all operations in the segment. The remaining model flow rates for hydrochloric acid pickling and sulfuric acid pickling were either transferred from the 1982 development document or from the Stainless Steel Segment (pickling).

EPA selected 700 gpt as the model flow rate for stainless steel acid pickling of strip and sheet instead of the median PNF of 874 gpt. The Agency considers the sites achieving the model flow rate (38 percent of the total) to be the better performing operations in this segment. EPA selected 35 gpt for stainless steel acid pickling of plate instead of the median of 33 gpt. Each of the sites that pickles plate was already achieving this flow rate and the Agency

determined that it would be cost-prohibitive to reduce the flow rate further. EPA transferred the remaining model flow rates for stainless steel acid pickling from the 1982 development document.

The Agency identified six zero discharge acid pickling lines during its analysis of the acid pickling subcategory. The Agency did not select zero discharge as the model flow for any of the acid pickling operations because sites would have to use options such as contract hauling of waste to achieve zero discharge. In addition, the Agency concluded that it was not feasible to achieve zero discharge on an industry-wide basis.

The Agency analyzed data from WAPC devices (e.g., absorber vent scrubbers) that acid regeneration operations reported operating. After reviewing the 1997 industry survey data and comparing it to the data used for the 1982 regulation, the Agency determined that the model flow rate of 100 gpm contained in the 1982 rule is still applicable.

7.8.2 Cold Forming

Sources

The Agency considered data from the 64 sites (integrated, non-integrated, stand-alone) that reported performing cold forming in their industry survey responses. Because some plants operate more than one cold forming operation, the total number of operations analyzed was 234. The Agency was unable to analyze data from two operations due to incomplete industry survey responses.

During the analysis, the Agency identified blowdown from the contact water and rolling solution systems as the primary source of wastewater. For the purposes of this manufacturing operation, the Agency made no distinction between contact spray water systems and rolling solution systems, which can include blowdown from roll and/or roll table spray cooling and product cooling. Other sources of wastewater included in the development of model PNFs were equipment cleaning water, wastewater from roll shops, and basement sumps.

Pollutants of Concern

Based on an analysis of EPA sampling data and industry-provided data from the Analytical and Production Survey, EPA determined that the principal pollutants from cold forming wastewater are TSS, O&G, and metals (lead and zinc for carbon and alloy steels and chromium and nickel for stainless steels; chromium may also be a contaminant from cold rolling of carbon steels resulting from wear on chromium-plated work rolls). EPA also found priority organic pollutants including naphthalene, other polynuclear aromatic compounds, and chlorinated solvents in cold rolling wastewater. EPA selected 26 POCs for cold forming operations in the Carbon and Alloy Steel Segment of the Steel Finishing Subcategory, presented in Table 7-10, and 40 POCs for cold forming operations in the Stainless Steel Segment of the Steel Finishing Subcategory, presented in Table 7-11.

Wastewater Flow Rates

The following table presents the selected model PNF, number of operations currently operating at the model PNF, and number of lines analyzed for carbon and alloy cold forming operations. Each of the selected model flow rates for carbon and alloy cold forming, except for single stand, recirculation, is slightly above the median PNF for each operation. EPA determined that it would be cost-prohibitive for all sites to achieve the median flow rate. For single stand, recirculation, EPA selected a flow rate below the median of 7 gpt. The Agency concluded that it was appropriate for single stand, recirculation, to have a lower flow rate than single stand, direct application. Therefore, EPA selected the model flow rate based on the three best performing mills in the category. The Agency did not select zero discharge as the model PNF for carbon and alloy cold forming operations because sites with a discharge from their recycle system(s) achieved zero discharge through either contract hauling or discharge to another process. The Agency concluded that contract hauling of waste is a not a universally applicable wastewater management approach and also recognizes that discharge to another process is not a viable option at all sites.

Carbon and Alloy Steel Cold Forming Model Flow Rates

Carbon and Alloy Cold Forming	Model PNF (gpt)	Operations Currently Operating at the Model PNF	Number of Operations Analyzed
Single stand, recirculation	1	3	18
Single stand, direct application	3	15	26
Multiple stand, recirculation	25	16	28
Multiple stand, direct application	275	11	19
Multiple stand, combination	143	5	8

The following table presents the selected model PNF, number of operations currently operating at the model PNF, and number of operations analyzed for stainless cold forming. The selected model flow rates for stainless cold forming are slightly above the median flow rates. EPA determined that it would be cost-prohibitive for all sites to achieve the median flow rate. The Agency did not select zero discharge as the model PNF for stainless steel cold forming operations for the reasons cited above. After reviewing the industry survey data, the Agency did not identify any sites operating multiple stand, direct application, or multiple stand, combination, rolling mills for stainless steels. The Agency transferred the model flow rates for these operations from the Carbon and Alloy Steel Segment, because of similarities in the manufacturing processes.

Stainless Steel Cold Forming Model Flow Rates

Stainless Steel Cold Forming	Model PNF (gpt)	Operations Currently Operating at the Model PNF	Number of Sites Reporting
Single stand, recirculation	3	7	13
Single stand, direct application	35	1	1
Multiple stand, recirculation	16	6	7
Multiple stand, direct application	275[a]	N/A	0
Multiple stand, combination	143[a]	N/A	0

[a]Value transferred from the Carbon and Alloy Steel Segment.
N/A = Not applicable.

7.8.3   Alkaline Cleaning

Sources

The Agency considered data from the 32 sites (integrated, non-integrated, and stand-alone) that indicated in their industry survey response that they performed alkaline cleaning operations on stand-alone process lines that do not have other processes such as pickling or coating. Because some plants operate more than one stand-alone alkaline cleaning operation, the total number of operations analyzed was 49. The Agency was unable to analyze data from one operation due to an incomplete survey response.

EPA has defined alkaline cleaning operations to include annealing operations on the same line; as a result, this segment includes both stand-alone alkaline cleaning lines and continuous annealing/alkaline cleaning lines. The Agency included annealing rinses, when present, in determining PNFs for the alkaline cleaning lines.

The primary sources of wastewater identified for alkaline cleaning operations were blowdown from the alkaline cleaning solution tanks and rinse water used to clean the alkaline cleaning solution from the steel. Other minor sources of wastewater included the following: rinse water from annealing operations (when operated with a water quench); runoff from raw material handling, preparation, and storage; tank clean-outs; and equipment cleaning and wash down water.

Pollutants of Concern

Based on an analysis of EPA sampling data and industry-provided data from the Analytical and Production Survey, EPA determined that the principal pollutant from alkaline cleaning operations is O&G removed from the steel. Because alkaline cleaning baths do not aggressively attack or dissolve the surface of the steel processed, metals are not as prevalent as in acid pickling wastewater. EPA selected 12 POCs for alkaline cleaning operations in the Carbon

and Alloy Steel Segment of the Steel Finishing Subcategory, presented in Table 7-10. EPA selected 10 POCs for alkaline cleaning operations in the Stainless Steel Segment of the Steel Finishing Subcategory, presented in Table 7-11.

Wastewater Flow Rates

When developing the model PNF for alkaline cleaning, the Agency included all process wastewater flows that were conveyed to treatment. If a wastewater discharge was contract hauled or recycled and reused, the Agency did not include the flow in the development of the model PNF. If a site's industry survey response indicated that a flow was both contract hauled and discharged to treatment, but did not specify the portion of flow going to each, the Agency used the combined flow to develop the PNF. Each of the selected model flow rates for alkaline cleaning approximates the median flow rate.

EPA selected 320 gpt as the model PNF for alkaline cleaning of carbon and alloy steel strip and sheet. Twelve of the 24 lines reported PNFs of less than 320 gpt. None of these sites reported lines operating without a discharge.

EPA selected 20 gpt as the model PNF for alkaline cleaning of carbon and alloy steel pipe and tube. Four of the six sites reported lines with PNFs of less than or equal to 20 gpt. One site reported operating without a discharge by contract hauling its wastewater. The Agency did not select zero discharge as the model flow for alkaline cleaning of pipe and tube because sites would have to use disposal methods such as contract hauling to achieve zero discharge.

EPA selected 2,500 gpt as the model PNF for alkaline cleaning of stainless strip. Nine of the 15 sites reported lines with PNFs of less than or equal to 2,500 gpt. None of the sites reported operating without a discharge. The Agency did not identify any sites that practiced alkaline cleaning of stainless steel pipe and tube. EPA transferred the model pipe and tube flow rate of 20 gpt from the Carbon and Alloy Steel Segment.

7.8.4   Continuous Annealing

Sources

The Agency considered data from the 11 sites that indicated in their industry survey responses that they performed stand-alone continuous annealing operations (i.e., not on the same process line with operations such as alkaline cleaning or acid pickling). Because some sites operate more than one stand-alone continuous annealing operation, the total number of operations analyzed was 28. The Agency was unable to analyze data from two operations due to incomplete survey responses.

Stand-alone continuous annealing operations only include annealing operations that are not considered to be part of any other finishing line operated by the site. Annealing operations with a water quench that generate a discharge on acid pickling, cold forming, hot

coating, alkaline cleaning, and electroplating lines are included in the model flow rate for these operations. Both the Carbon and Alloy Steel and Stainless Steel Segments have stand-alone continuous annealing operations that are divided into two categories: lines that do and lines that do not use water to quench the steel after the annealing process.

Pollutants of Concern

EPA did not identify any POCs for this manufacturing process because EPA did not sample any annealing quenching operations. However, because quenching is simply a direct-contact water cooling process with no chemicals involved, the Agency determined that wastewater associated with this operation is unlikely to contain pollutants not already selected as POCs in other finishing manufacturing process divisions.

Wastewater Flow Rates

EPA selected 20 gpt (the median flow rate) as the model PNF for stand-alone continuous annealing with a water quench. Seven of the 14 lines with a water quench reported PNFs of less than or equal to 20 gpt. None of the sites reported operating without a discharge. Stand-alone continuous annealing lines that operate without a water quench do not generate process wastewater and have been designated as a zero-discharge operation.

7.8.5 Hot Coating

Sources

The Agency considered data from the 26 sites (integrated, non-integrated, and stand-alone) that indicated in their industry survey responses that they performed hot coating. Because some plants operate more than one hot coating line, the total number of lines analyzed was 40. The Agency was unable to analyze data from five lines due to incomplete survey responses. Hot coating operations are performed on carbon and alloy steels only. EPA has defined hot coating lines as including acid cleaning, annealing, alkaline cleaning, and other surface cleaning and preparation operations on the same line.

The primary source of wastewater from hot coating operations is the surface preparation operations, such as acid and alkaline cleaning, that the steel undergoes before hot coating. Four of the operations reported a discharge from their hot coating tanks. Thirty-two of the operations reported having a rinse following the coating operation. Tank clean-outs, fume scrubbers, and equipment cleaning are other sources of wastewater reported by a number of sites.

Pollutants of Concern

Based on an analysis of EPA sampling data and industry-provided data from the Analytical and Production Survey, EPA determined that the principal pollutants from hot coating wastewater are TSS, O&G, metals from the surface preparation operations, and hexavalent

chromium from lines with chromium brightening or passivation operations. EPA selected 23 POCs for hot coating operations in the Carbon and Alloy Steel Segment of the Steel Finishing Subcategory, presented in Table 7-10.

Wastewater Flow Rates

The Agency analyzed data from WAPC devices that were reported as being operated on hot coating lines. After reviewing the 1997 industry survey data and comparing it to the data used for the 1982 rule, the Agency determined that the model flow rate of 15 gpm contained in the 1982 rule is still applicable.

In developing the model PNF, the Agency only considered flow rates that were conveyed to treatment systems. When responding to the industry survey, sites had the option of indicating if they discharged process wastewater to treatment and/or disposed of it via several different zero discharge methods. If a site listed a zero discharge disposal method for a discharge, EPA did not use that discharge in the development of the model PNF. If a site's industry survey response indicated that a flow was both discharged to treatment and disposed of using a zero discharge method, but did not specify the portion of flow rate going to each, the Agency used the combined flow to develop the PNF.

EPA selected 550 gpt as the model PNF for hot coating operations. Twenty-eight of the 40 lines reported having PNFs of less than or equal to 550 gpt. Two of the lines reported operating without a discharge by using contract hauling. EPA determined that it would be cost-prohibitive for all sites to achieve the median PNF of 182 gpt. The Agency did not select zero discharge as the model flow for hot coating because sites would have to use disposal methods such as contract hauling to achieve zero discharge.

7.8.6   Electroplating

Sources

The Agency considered data from the 23 sites (integrated, non-integrated, and stand-alone) that indicated in their industry survey responses that they performed electroplating. Because some plants operate more than one electroplating line, the total number of operations analyzed was 44. The Agency was unable to analyze data from two operations due to incomplete survey responses. EPA has defined electroplating lines as annealing, alkaline cleaning, acid cleaning, and other surface cleaning and surface preparation operations on the same line.

The primary sources of wastewater from electroplating operations are acid and alkaline cleaning operations performed on the same process line, plating solution losses, and fume scrubbers. Tank clean-outs and equipment cleaning are other sources of wastewater reported by a number of sites.

Pollutants of Concern

Based on an analysis of EPA sampling data and industry-provided data from the Analytical and Production Survey, EPA determined that the principal pollutants from electroplating wastewater are TSS and O&G generated from the precleaning operations and the metals from plating solution losses, rinsing, and fume scrubbers. EPA selected 19 POCs for electroplating operations in the Carbon and Alloy Steel Segment of the Steel Finishing Subcategory (as selected in at least one of the following types of electroplating: tin, tin-chromium, zinc, or zinc-nickel), presented in Table 7-10.

Wastewater Flow Rates

The Agency analyzed data from WAPC devices that were reported as being operated on electroplating lines. After reviewing the 1997 industry survey data and comparing it to the data used for the 1982 regulation, the Agency determined that the model flow rate of 15 gpm contained in the 1982 effluent guidelines is still applicable.

In developing the model PNF, the Agency only considered flow rates that were conveyed to treatment systems. When responding to the industry survey, sites had the option of indicating whether they discharged their process wastewater to treatment and/or disposed of it via several different zero discharge disposal methods. If a site listed a zero discharge disposal method for discharge, EPA did not use that discharge in the development of the model PNF. If a site's industry survey response indicated that a flow was both discharged to treatment and disposed of using a zero discharge method, but did not specify the portion of flow going to each, the Agency used the combined flow to develop the PNF.

The model PNF for electroplating operations varies by the type of metal applied and the product type. The Agency chose a model PNF of 1,100 gpt for tin and chromium lines plating strip steel. Ten of the 20 lines reported PNFs equal to or less than 1,100 gpt. The Agency chose a model PNF of 550 gpt for lines plating strip steel with metals other than tin or chromium. Sixteen of the 20 lines reported PNFs equal to or less than 550 gpt. EPA determined that it would be cost-prohibitive for all sites to achieve the median PNF of 214 gpt. The Agency chose a model PNF of 35 gpt for electroplating of steel plate. Because the data for plate electroplating are confidential, they are not presented here. EPA concluded that the selected flow rates are achievable by well-operated electroplating operations.

7.9 Other Operations Subcategory

The subcategory the Agency proposes for other operations encompasses segments for direct reduced ironmaking, forging, and briquetting.

7.9.1   Directed Reduced Ironmaking (DRI) Segment

Sources

Three DRI plants provided industry survey data. One plant was operated at a non-integrated site and two were operated as stand-alone DRI sites. One plant began operations after 1997, but was considered for the development of the model flow rate. WAPC systems are the only reported process wastewater source for DRI operations. The WAPCs control furnace emissions and emissions from material handling and storage.

Pollutants of Concern

Based on an analysis of EPA sampling data and industry-provided data from the Analytical and Production Survey, EPA determined that the principal pollutant from DRI operations is TSS. EPA selected 10 POCs for the DRI Segment of the Other Operations Subcategory, presented in Table 7-12.

Wastewater Flow Rates

An evaluation of the three sites that conducted DRI operations found that they recycle scrubber wastewater. Based on the practice of wastewater recycle, the Agency selected a model PNF of 90 gpt; two of the three DRI plants are achieving this model flow rate.

7.9.2   Forging Segment

Sources

The Agency determined that forging operations are similar to other hot forming operations with respect to wastewater characteristics based on process considerations. Sixteen industry survey respondents indicated that they conducted forging operations in 1997 at eight non-integrated and four stand-alone sites. Contact water and hydraulic system wastewater comprise most of the process wastewater from forging operations. Contact water is used for flume flushing, descaling, die spray cooling, and product quenching. Some sites identified equipment cleaning water and basements sumps as other sources of wastewater from forging operations.

Pollutants of Concern

Based on an analysis of industry-provided data, EPA determined that the principal pollutants from forging are TSS, O&G, and metals. EPA did not identify any POCs for the Forging Segment because EPA did not sample any forging operations.

Wastewater Flow Rates

EPA calculated 15 PNFs based on available industry survey data. The Agency based its development of model treatment for forging operations on similar wastewater treatment for hot forming operations. As with hot forming, the Agency determined that wastewater treatment systems treating forging wastewaters demonstrate a recycle rate of 96 percent. High-rate recycle is a principle component of forging wastewater treatment and EPA used it to select a model flow rate. EPA selected a model PNF of 100 gpt for forging operations. This model flow rate is demonstrated at nine of the 16 forging operations that were analyzed.

7.9.3   Briquetting Segment

The Agency found that briquetting operations do not generate or discharge process wastewater. Therefore, the Agency has designated briquetting as a zero discharge operation.

7.10   <u>References</u>

7-1   U.S. Environmental Protection Agency. <u>Development Document for Effluent Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category</u>. Volume 1. EPA 440/1-82/024, Washington, D.C., May 1982.

Table 7-1

1997 National Estimate of Annual Discharge from Manufacturing Operations by Discharge Type

Manufacturing Operation	Total Number of Sites[a]	Total Annual Discharge Rate (1,000 gallons per year)	Number (%) of Direct Dischargers	Annual Discharge Rate for Direct Dischargers (1,000 gallons per year)	Number (%) of Indirect Dischargers	Annual Discharge Rate for Indirect Dischargers (1,000 gallons per year)	Number (%) of Zero Dischargers[b]
Cokemaking	24	3,031,000	14 (58%)	2,450,000	8 (33%)	581,000	2 (8%)
Sintering	9	2,110,000	4 (44%)	2,110,000	0[3] (0%)	0[c]	5 (56%)
Blast furnace ironmaking	20	7,914,000	13 (62%)	7,630,000	1 (5%)	284,000	7 (33%)
BOF steelmaking	20	6,371,110	17 (81%)	6,370,000	1 (5%)	1,110	3 (14%)
EAF steelmaking	96	0[c]	3 (3%)	0[c]	2 (2%)	0[c]	92 (96%)
Vacuum degassing	44	1,270,000	26 (59%)	1,250,000	4 (9%)	20,000	14 (32%)
Ladle metallurgy	103	0[c]	0[c] (0%)	0[c]	0[c] (0%)	0[c]	103 (100%)
Continuous Casting	113	10,573,000	53 (47%)	10,100,000	17 (15%)	473,000	43 (38%)
Hot forming	153	140,772,000	87 (57%)	140,000,000	29 (19%)	772,000	39 (25%)
Acid pickling and descaling	69	13,755,000	50 (72%)	13,400,000	14 (20%)	355,000	7 (10%)
Cold forming	103	9,479,600	39 (38%)	9,420,000	16 (16%)	59,600	52 (50%)
Surface cleaning and coating[d]	98	14,519,000	53 (54%)	13,800,000	33 (34%)	719,000	14 (14%)
Briquetting or other agglomeration process	4	0[c]	0[c] (0%)	0[c]	0[c] (0%)	0[c]	4 (100%)
Direct reduced ironmaking	2	119,000	1 (50%)	78,600	1 (50%)	40,500	0[d] (0%)

Source: U.S. EPA, <u>U.S. EPA Collection of 1997 Iron and Steel Industry Data</u> (Detailed and Short Surveys).

[a]The sum of direct, indirect, and zero dischargers may not equal the total number of operations. Sites may discharge wastewater both directly and indirectly from their manufacturing operations.
[b]Zero dischargers include operations that do not discharge process wastewater as well as operations that are completely dry.
[c]Cells with a zero (0) indicate that none of the survey respondents have the characteristic; however, it is possible for nonsurveyed facilities to have the characteristic.
[d]Surface cleaning and coating operations include: alkaline cleaning, stand-alone continuous annealing, hot coating, and electroplating.

Table 7-2

Pollutants of Concern
Cokemaking Subcategory - By-Product Segment

Pollutant Group	Pollutant of Concern
Conventional pollutants	Biochemical oxygen demand 5-day (BOD$_5$)
	Biochemical oxygen demand 5-day (BOD$_5$) - carbonaceous
	Oil and grease (O&G)
	Total suspended solids (TSS)
Nonconventional pollutants	Amenable cyanide
	Ammonia as nitrogen
	Chemical oxygen demand (COD)
	Nitrate/nitrite
	Total petroleum hydrocarbons (TPH)
	Thiocyanate
	Total Kjeldahl nitrogen (TKN)
	Total organic carbon (TOC)
	Total phenols
	Weak acid dissociable (WAD) cyanide
Priority metals	Arsenic
	Mercury
	Selenium
Nonconventional metals	Boron
Priority organic constituents	Acenaphthene
	Acenaphthylene
	Anthracene
	Benzidine
	Benzo(a)anthracene
	Benzo(b)fluoranthene
	Benzo(k)fluoranthene
	Benzo(ghi)perylene
	Benzo(a)pyrene
	Chrysene
	2,4-dimethylphenol

Table 7-2 (Continued)

Pollutant Group	Pollutant of Concern
Priority organic constituents (cont.)	Fluoranthene
	Fluorene
	Indeno(1,2,3-cd)pyrene
	Naphthalene
	Phenanthrene
	Phenol
	Pyrene
	Benzene
	1,2-Dichloroethane
	Ethylbenzene
	Toluene
Nonconventional organic constituents	Aniline
	2,3-Benzofluorene
	Biphenyl
	Carbazole
	o-Cresol
	p-Cresol
	Dibenzofuran
	Dibenzothiophene
	n-Eicosane
	n-Hexadecane
	4,5-Methylene phenanthrene
	2-Methylnaphthalene
	1-Methylphenanthrene
	1-Naphthylamine
	beta-Naphthylamine
	n-Octadecane
	Perylene
	2-Phenylnaphthalene
	2-Picoline
	Pyridine

Table 7-2 (Continued)

Pollutant Group	Pollutant of Concern
Nonconventional organic constituents (continued)	Styrene
	Thianaphthene
	o-Toluidine
	2-Propanone
	Carbon disulfide
	2-Butanone
	m-Xylene
	m- + p-Xylene
	o-Xylene
	o- + p-Xylene
Other priority pollutants	Total cyanide

Table 7-3

Pollutants of Concern
Ironmaking Subcategory - Sintering Segment

Pollutant Group	Pollutant of Concern
Conventional pollutants	Oil and grease (O&G)
	Total suspended solids (TSS)
Nonconventional pollutants	Amenable cyanide
	Ammonia as nitrogen
	Chemical oxygen demand (COD)
	Fluoride
	Nitrate/Nitrite
	Total petroleum hydrocarbons (TPH)
	Thiocyanate
	Total Kjeldahl nitrogen (TKN)
	Total organic carbon (TOC)
	Total phenols
	Weak acid dissociable (WAD) cyanide
Priority metals	Arsenic
	Cadmium
	Chromium
	Copper
	Lead
	Mercury
	Selenium
	Silver
	Thallium
	Zinc
Nonconventional metals	Aluminum
	Boron
	Iron
	Magnesium
	Manganese
	Titanium

Table 7-3 (Continued)

Pollutant Group	Pollutant of Concern
Priority organic constituents	Benzo(a)anthracene
	Benzo(b)fluoranthene
	Benzo(k)fluoranthene
	Benzo(a)pyrene
	Chrysene
	2,4-Dimethylphenol
	Fluoranthene
	4-Nitrophenol
	Phenanthrene
	Phenol
	Pyrene
Nonconventional organic constituents	n-Tetracosane
	n-Docosane
	n-Eicosane
	n-Hexadecane
	n-Octadecane
	o-Cresol
	p-Cresol
	Pyridine
	1,2,3,7,8-Pentachlorodibenzo-p-dioxin
	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin
	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin
	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin
	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin
	Octachlorodibenzo-p-dioxin
	2,3,7,8-Tetrachlorodibenzofuran
	1,2,3,7,8-Pentachlorodibenzofuran
	2,3,4,7,8-Pentachlorodibenzofuran
	1,2,3,4,7,8-Hexachlorodibenzofuran
	1,2,3,6,7,8-Hexachlorodibenzofuran
	1,2,3,7,8,9-Hexachlorodibenzofuran

Table 7-3 (Continued)

Pollutant Group	Pollutant of Concern
Nonconventional organic constituents (continued)	2,3,4,6,7,8-Hexachlorodibenzofuran
	1,2,3,4,6,7,8-Heptachlorodibenzofuran
	1,2,3,4,7,8,9-Heptachlorodibenzofuran
	Octachlorodibenzofuran
Other priority pollutants	Total cyanide

Table 7-4

Pollutants of Concern
Ironmaking Subcategory - Blast Furnace Segment

Pollutant Group	Pollutant of Concern
Conventional pollutants	Oil and grease (O&G)
	Total suspended solids (TSS)
Nonconventional pollutants	Amenable cyanide
	Ammonia as nitrogen
	Chemical oxygen demand (COD)
	Fluoride
	Nitrate/Nitrite
	Total petroleum hydrocarbons (TPH)
	Thiocyanate
	Total Kjeldahl nitrogen (TKN)
	Total organic carbon (TOC)
	Weak acid dissociable (WAD) cyanide
Priority metals	Chromium
	Copper
	Lead
	Nickel
	Selenium
	Zinc
Nonconventional metals	Aluminum
	Boron
	Iron
	Magnesium
	Manganese
	Molybdenum
	Titanium
Nonconventional organic constituents	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin
Other priority pollutants	Total cyanide

Table 7-5

**Pollutants of Concern
Integrated Steelmaking Subcategory**

Pollutant Group	Pollutant of Concern	BOF Furnaces	Vacuum Degassing	Continuous Casting
Conventional pollutants	Oil and grease (O&G)	✔	✔	✔
	Total suspended solids (TSS)	✔	✔	✔
Nonconventional pollutants	Ammonia as nitrogen	✔	✔	
	Chemical oxygen demand (COD)	✔	✔	✔
	Fluoride	✔	✔	✔
	Nitrate/Nitrite	✔		
	Total petroleum hydrocarbons (TPH)	✔	✔	✔
	Total organic carbon (TOC)	✔		✔
Priority metals	Antimony	✔		✔
	Beryllium	✔		
	Cadmium	✔		
	Chromium	✔		
	Copper	✔	✔	
	Lead	✔	✔	✔
	Mercury	✔		
	Nickel	✔		
	Silver	✔		
	Zinc	✔	✔	✔
Nonconventional metals	Aluminum	✔	✔	✔
	Cobalt	✔		
	Iron	✔	✔	✔
	Magnesium	✔		
	Manganese	✔	✔	✔
	Molybdenum	✔	✔	✔
	Tin	✔	✔	
	Titanium	✔	✔	
	Vanadium	✔		
Priority organic constituents	Phenol	✔		

Table 7-6

Pollutants of Concern
Integrated and Stand-Alone Hot Forming Subcategory -
Carbon and Alloy Steel Segment

Pollutant Group	Pollutant of Concern
Conventional pollutants	Oil and grease (O&G)
	Total suspended solids (TSS)
Nonconventional pollutants	Ammonia as nitrogen
	Chemical oxygen demand (COD)
	Fluoride
	Total petroleum hydrocarbons (TPH)
Priority metals	Lead
	Zinc
Nonconventional metals	Iron
	Manganese
	Molybdenum

Table 7-7

Pollutants of Concern
Integrated and Stand-Alone Hot Forming Subcategory -
Stainless Steel Segment

Pollutant Group	Pollutant of Concern
Conventional pollutants	Oil and grease (O&G)
	Total suspended solids (TSS)
Nonconventional pollutants	Chemical oxygen demand (COD)
	Fluoride
	Total petroleum hydrocarbons (TPH)
	Total organic carbon (TOC)
Priority metals	Antimony
	Chromium
	Copper
	Nickel
	Zinc
Nonconventional metals	Iron
	Manganese
	Molybdenum
	Titanium

Table 7-8

Pollutants of Concern
Non-Integrated Steelmaking and Hot Forming Subcategory -
Carbon and Alloy Steel Segment

Pollutant Group	Pollutant of Concern	Continuous Casting	Hot Forming
Conventional pollutants	Oil and grease (O&G)	✔	✔
	Total suspended solids (TSS)	✔	✔
Nonconventional pollutants	Ammonia as nitrogen	✔	
	Chemical oxygen demand (COD)	✔	
	Total petroleum hydrocarbons (TPH)	✔	✔
	Total organic carbon (TOC)	✔	✔
Priority metals	Lead	✔	✔
	Zinc	✔	✔
Nonconventional metals	Iron		✔
	Manganese		✔

Table 7-9

**Pollutants of Concern
Non-Integrated Steelmaking and Hot Forming Subcategory -
Stainless Steel Segment**

Pollutant Group	Pollutant of Concern	Continuous Casting	Hot Forming
Conventional pollutants	Oil and grease (O&G)	✔	✔
	Total suspended solids (TSS)	✔	✔
Nonconventional pollutants	Ammonia as nitrogen	✔	
	Chemical oxygen demand (COD)	✔	✔
	Fluoride	✔	✔
	Nitrate/Nitrite	✔	
	Total petroleum hydrocarbons (TPH)	✔	✔
	Total organic carbon (TOC)	✔	✔
Priority metals	Antimony		✔
	Chromium	✔	✔
	Copper	✔	✔
	Lead	✔	
	Nickel	✔	✔
	Zinc	✔	✔
Nonconventional metals	Aluminum	✔	
	Boron	✔	
	Hexavalent chromium	✔	
	Iron	✔	✔
	Manganese	✔	✔
	Molybdenum	✔	✔
	Titanium	✔	✔
Priority organic constituents	Tribromomethane	✔	

Table 7-10

Pollutants of Concern
Steel Finishing Subcategory - Carbon and Alloy Steel Segment

Pollutant Group	Pollutant of Concern	Acid Pickling	Cold Forming	Alkaline Cleaning	Hot Coating	Electro-plating
Conventional pollutants	Oil and grease (O&G)	✔	✔	✔	✔	✔
	Total suspended solids (TSS)	✔	✔	✔	✔	✔
Nonconventional pollutants	Ammonia as nitrogen	✔	✔	✔	✔	✔
	Chemical oxygen demand (COD)	✔	✔	✔	✔	✔
	Fluoride	✔	✔	✔	✔	✔
	Nitrate/Nitrite	✔			✔	✔
	Total petroleum hydrocarbons (TPH)	✔	✔	✔	✔	✔
	Total organic carbon (TOC)	✔	✔	✔	✔	✔
	Total phenols		✔			
	Sulfate	✔				
Priority metals	Antimony				✔	
	Arsenic	✔	✔		✔	
	Chromium	✔	✔		✔	✔
	Copper	✔	✔	✔	✔	✔
	Lead				✔	✔
	Nickel	✔	✔		✔	✔
	Selenium					✔
	Zinc	✔	✔	✔	✔	✔
Nonconventional metals	Aluminum		✔		✔	
	Boron				✔	
	Hexavalent chromium				✔	✔
	Iron	✔	✔	✔	✔	✔
	Manganese	✔	✔	✔	✔	✔
	Molybdenum				✔	✔
	Tin			✔	✔	
	Titanium	✔	✔		✔	✔
Priority organic constituents	Bis(2-ethylhexyl) phthalate		✔			
	1,1,1-Trichloroethane		✔			

Table 7-10 (Continued)

Pollutant Group	Pollutant of Concern	Acid Pickling	Cold Forming	Alkaline Cleaning	Hot Coating	Electro-plating
Nonconventional organic constituents	alpha-Terpineol		✔			
	Benzoic acid		✔			
	n,n-Dimethylformamide	✔				
	n-Dodecane		✔			
	n-Eicosane		✔			
	n-Hexadecane		✔			
	n-Octadecane		✔			
	n-Tetradecane		✔			
	2-Propanone	✔				

Note: Pollutants of concern were not selected for the annealing manufacturing process.

Table 7-11

Pollutants of Concern
Stainless Finishing Subcategory - Stainless Steel Segment

Pollutant Group	Pollutant of Concern	Acid Pickling	Alkaline Cleaning	Cold Forming
Conventional pollutants	Oil and grease (O&G)	✔	✔	✔
	Total suspended solids (TSS)	✔	✔	✔
Nonconventional pollutants	Ammonia as nitrogen	✔	✔	✔
	Chemical oxygen demand (COD)	✔	✔	✔
	Fluoride	✔	✔	✔
	Nitrate/Nitrite	✔		
	Total petroleum hydrocarbons (TPH)	✔	✔	✔
	Total cyanide	✔		
	Total organic carbon (TOC)	✔		✔
	Total phenols			✔
Priority metals	Antimony	✔		✔
	Arsenic	✔		✔
	Cadmium	✔		✔
	Chromium	✔		✔
	Copper	✔		✔
	Lead	✔		
	Nickel	✔		✔
	Selenium	✔		
	Zinc	✔		✔
Nonconventional metals	Aluminum	✔		✔
	Barium	✔		
	Boron	✔		
	Cobalt	✔		
	Hexavalent chromium	✔		✔
	Iron	✔	✔	✔
	Magnesium	✔	✔	
	Manganese	✔	✔	✔

Table 7-11 (Continued)

Pollutant Group	Pollutant of Concern	Acid Pickling	Alkaline Cleaning	Cold Forming
Nonconventional metals (continued)	Molybdenum	✔		✔
	Tin	✔		✔
	Titanium	✔	✔	✔
	Vanadium	✔		
Priority organic constituents	Naphthalene			✔
	Phenol			✔
	Ethylbenzene			✔
	Toluene			✔
Nonconventional organic constituents	2,6-Di-tert-butyl-p-benzoquinone			✔
	2-Methylnaphthalene			✔
	Benzoic acid			✔
	Hexanoic acid			✔
	n-Docosane			✔
	n-Dodecane			✔
	n-Eicosane			✔
	n-Hexadecane			✔
	n-Octadecane			✔
	n-Tetracosane			✔
	n-Tetradecane			✔
	2-Propanone			✔
	m-Xylene			✔
	o- + p-Xylene			✔

Note: Pollutants of concern were not selected for the annealing manufacturing process.

Table 7-12

Pollutants of Concern
Other Operations Subcategory - Direct Reduced Ironmaking Segment

Pollutant Group	Pollutant of Concern
Conventional pollutants	Oil and grease (O&G)
	Total suspended solids (TSS)
Nonconventional pollutants	Ammonia as nitrogen
	Chemical oxygen demand (COD)
	Fluoride
	Total petroleum hydrocarbons (TPH)
Nonconventional metals	Aluminum
	Iron
	Manganese
	Titanium

SECTION 8

TECHNOLOGY OPTIONS

This section describes the technology options that EPA evaluated in developing the effluent limitations guidelines and standards proposed for the iron and steel industry. To determine the model treatment technologies, model discharge flow rate, and effluent quality for the proposed regulation, EPA developed a database of the following:

- In-process technologies and process modifications;
- Process water recycle technologies;
- End-of-pipe wastewater treatment technologies;
- Process wastewater discharge flow rates; and
- Treated process wastewater effluent quality.

EPA collected most data were collected from the analytical and production survey and the EPA wastewater sampling programs. As described in Section 3, the Agency also used other data sources.

Although EPA has wide discretion to establish BAT effluent limitations guidelines on a range of technologies, including transfer of technologies from other industries and in-process controls, even when not common industry practice, the technology options considered for this proposed regulation are generally well demonstrated in the iron and steel industry. The Clean Water Act does not require that dischargers achieve technology-based effluent limitations and categorical pretreatment standards by using the technologies considered by EPA when promulgating the effluent limitations guidelines and standards regulations. Rather, the Clean Water Act requires compliance with numerical NPDES permit and pretreatment limits derived from the effluent limitations guidelines and standards. Direct and indirect dischargers can use any combination of process modifications, in-process technologies, and wastewater treatment technologies.

Section 8.1 summarizes the in-process and end-of-pipe treatment technologies considered by EPA, and Section 8.2 summarizes the technology options (model treatment systems) EPA evaluated for the proposed effluent limitations guidelines and standards.

8.1   Technology Overview

This section discusses the types of technologies in place at iron and steel sites and other industrial wastewater treatment. Many wastewater treatment technologies apply to multiple subcategories; therefore, this section presents technologies in general order by manufacturing process and then by the typical treatment train for each technology. Section 8.1.1 discusses in-process technologies, and Section 8.1.2 discusses end-of-pipe technologies.

8.1.1　　　　In-Process Technologies

Wastewater management practices for wet air pollution controls (WAPCs) for blast furnaces, sintering operations, and wet-open or wet-suppressed basic oxygen furnaces (BOFs) focus on the treatment and recycle of large volumes of contaminated gas cleaning wastewater. The use of high-rate recycle can reduce annual discharges by 95 percent or greater.

Common pollutants in blast furnace gas cleaning wastewater include total suspended solids (TSS), ammonia, cyanides, phenolic compounds, and metals. Wastewater from sintering operations also contains these pollutants, along with oil and grease (O&G) and dioxins and furans. Wastewater from gas cooling and cleaning systems associated with BOFs is contaminated with TSS and metals. To limit the pollutant loadings and volume of water discharge associated with the WAPC from the above-mentioned operations, high-rate recycle systems consisting of solids removal devices such as classifiers and clarifiers for removal of suspended solids are used to treat wastewater before reuse for gas cooling and cleaning. Blast furnace recycle systems also use cooling towers prior to reuse in gas cleaning systems. Carbon dioxide injection prior to clarification can be used for wet-open combustion and wet-suppressed combustion BOF recycle systems to remove scale-forming metal ions from wastewater before reuse. Solids recovered from classifiers, clarifiers, and scale pits have a significant iron content and may be processed at sintering or briquetting operations and then charged to a blast furnace. To prevent the accumulation of other contaminants in the high-rate recycle system, a small portion of the high-rate recycle stream is continuously discharged (blowdown), and makeup water is added. Blowdown is then treated at an end-of-pipe treatment system before discharge.

High-rate recycle systems are also used for vacuum degassing, continuous casting, and hot forming operations. Typical vacuum degassing high-rate recycle systems consist of clarifiers and cooling towers, with blowdown treated individually or with blowdown from continuous caster recycle systems. Typical components of high-rate recycle systems are scale pits with oil skimming, additional O&G and solids removal through clarification or filtration, and cooling towers. Principal pollutants from vacuum degassing wastewater are TSS and metals. Common pollutants from continuous casting and hot forming operations are TSS, O&G, and metals. Scale recovered from scale pits has a significant iron content and may be processed at sintering or briquetting operations and then charged to a blast furnace.

The following paragraphs provide additional information regarding equipment associated with the high-rate recycle systems discussed. Section 8.1.2 provides information on clarifiers, multimedia filtration, solids-handling equipment, and cooling towers, all of which are also common end-of-pipe treatment technologies.

- ***Scale Pits with Oil Skimming.*** Scale pits provide primary sedimentation and oil separation for untreated process wastewater generated by continuous casting and hot forming operations. Scale pits remove large, easily settleable iron scale. Pits are scraped or dredged and the iron scale is recovered for reuse or landfilled on or off site. Skimmed oil is typically collected on site and shipped off site for reclamation.

- • **Classifiers.** Classifiers provide primary sedimentation of high-volume untreated wastewater from wet-suppressed and wet-open BOF WAPC systems. Solids can be removed using screw or rake systems.

- • **Carbon Dioxide Injection**. Carbon dioxide injection is one method to remove scale-forming metal ions (hardness) from BOF recycle water in wet-open and wet-suppressed combustion systems. Carbonate precipitation occurs in the recycle system through injection of carbon dioxide (CO_2) prior to clarification. Carbon dioxide is injected through a very fine bubble diffusion assembly which is located in a basin with a minimum water depth of 10 feet. Liquid CO_2 can be stored on site and preheated prior to injection to create CO_2 gas. A series of baffles or a mixer directly above the CO_2 injection point help keep the bubbles submerged as long as possible. This action forms carbonic acid and bicarbonate alkalinity as illustrated by Equation 8-1 below:

$$H_2O + CO_2 \text{-------> } H_2CO_3 \text{--------> } H^+ + HCO_3^- \qquad\qquad (8\text{-}1)$$

    Carbonate reacts with magnesium and calcium ions to form insoluble precipitate, which is removed in the clarifier, by Equation 8-2 below:

$$Ca^{2+} + Mg^{2+} + 2HCO_3 + heat \text{-----> } CaCO_3\downarrow + CO_2 + H_2O \qquad\qquad (8\text{-}2)$$

    Carbon dioxide injection can potentially reduce effluent hardness levels to 10 - 15 mg/L as $CaCO_3$.

Stainless, alloy, or carbon steel finishing mills process hot rolled steel through a combination of acid pickling, cold rolling, alkaline cleaning, hot coating, and electroplating operations. Based on responses to the industry survey, hot coating and electroplating are only performed on carbon and alloy steel. Pollutants include oils from cold rolling operations and alkaline cleaning, hexavalent chromium from hot dip coating and electroplating of carbon steel or acid pickling of stainless steel, and metals from acid pickling and electroplating. In-process alternatives for finishing mills include countercurrent rinsing to limit water usage, ion exchange, and evaporation to recover acids and metals before end-of-pipe treatment. Training, housekeeping, and record-keeping can also be effective management alternatives for steel finishing operations. Below are additional details on each of these in-process practices.

- • **Countercurrent Rinsing.** Countercurrent cascade rinsing refers to a series of consecutive rinse tanks that are plumbed to cause water to flow from one tank to another in the direction opposite of the product flow. Fresh water flows into the rinse tank located farthest from the process tank and overflows, in turn, to the rinse tanks closer to the process tank. This technique is called countercurrent rinsing, because the product and the rinse water move in opposite directions. Over time, the first rinse becomes contaminated with drag-out solution and reaches a stable concentration

that is lower than the process solution. The second rinse stabilizes at a lower concentration, which enables less rinse water to be used than if only one rinse tank were in place. The more countercurrent cascade rinse tanks (three-stage, four-stage, etc.), the less water is needed to adequately remove the process solution.

The rinse rate needed to adequately dilute drag-out solution depends on the concentration of process chemicals in the initial process bath, the concentration of chemicals that can be tolerated in the final rinse tank to meet product specifications, the amount of drag-out carried into each rinse stage, and the number of countercurrent cascade rinse tanks. These factors are expressed in Equation 8-3 below:

$$V_r = \left(\frac{C_o}{C_f} \right)^{1/n} \times V_D \qquad\qquad (8\text{-}3)$$

where:

V_r = Flow through each rinse stage, gal/min
C_o = Concentration of the contaminant(s) in the initial process bath, mg/L
C_f = Tolerable concentration of the contaminant(s) in the final rinse to give acceptable product cleanliness, mg/L
n = Number of rinse stages used
V_D = Drag-out carried into each rinse stage, expressed as a flow, gal/min.

This mathematical rinsing model is based on complete rinsing (i.e., removal of all contaminants from the product) and complete mixing (i.e., homogeneous rinse water). Under these conditions, each additional rinse stage can reduce rinse water use by 90 percent. These conditions are not achieved unless there is sufficient residence time and agitation in the rinse tank. For less efficient rinse systems, each added rinse stage reduces rinse water use by 50 to 75 percent.

Countercurrent cascade rinsing systems have a higher capital cost than an overflow rinse and require more space due to the additional rinse tanks. Also, when countercurrent cascade rinsing is used, the low flow rate through the rinse tanks may not provide the needed agitation for drag-out removal. In such cases, air or mechanical agitation is added to increase rinsing efficiency.

- ***Recycle of Fume Scrubber Water.*** The steel finishing industry commonly uses fume scrubbers to capture acid gases. Scrubber water, which may

contain a dilute caustic solution, is neutralized and continuously recycled to adsorb acid. Makeup water is added to replace water lost through evaporation and water which is blown down to treatment. Blowdown is discharged to end-of-pipe treatment to prevent salts buildup.

- *Hydrochloric Acid Regeneration.* This process consists of thermal decomposition of spent pickle liquor, which contains free hydrochloric acid, ferrous chloride, and water. The liquor is heated to remove some of the water through evaporation and to concentrate the solution. The concentrated solution is then further heated to $925°C$ to $1,050°C$. At this temperature, water is completely evaporated and the ferrous chloride decomposes into iron oxide (ferric oxide, Fe_2O_3) and hydrogen chloride (HCl) gas. Equation 8-4 below shows the decomposition process:

  $$4\ FeCl_2 + 4\ H_2O + O_2 \text{-----}> 8\ HCl + 2\ Fe_2O_3 \tag{8-4}$$
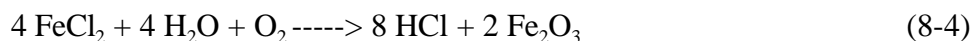
  The iron oxide is separated and removed from the system. The hydrogen chloride gas is reabsorbed in water (sometimes rinse water or scrubber water is used), to produce hydrochloric acid solution (generally from 15 percent to 21 percent HCl) which is reused in the pickling operation. There are several types of "roaster" types of process in operation. The basic differences among the processes are the design and operation of the roaster/reactor and the recovery equipment (Reference 8-3).

- *Effluent-Free Pickling Process with Fluid Bed Hydrochloric Acid Regeneration.* This pickling process can be operated such that no wastewater is discharged from spent pickle liquor, rinse wastewater, and scrubber water from a hydrochloric acid pickling line. The process is configured as a closed system that uses a fluidized bed reactor "roaster" configuration (hydrochloric acid regeneration is explained in detail above) to thermally decompose spent pickle liquor to hydrochloric acid and iron oxide (Reference 8-4).

  Spent pickle liquor is fed via a settling tank and venturi loop into the fluidized bed inside the reactor. The thermal energy from the fluidized bed off-gases is used to concentrate the pickling liquor by evaporation before it is fed to the reactor. The fluidized bed consists of granulated iron oxide. Residual acid and water are evaporated at $850°C$ and the iron chloride is converted to hydrochloric acid gas. Growth and new formation of iron oxide grains in the fluidized bed are controlled so that a dust-free granulated product is obtained. The iron oxide grains can be used as a raw material to manufacture other products (e.g., as an additive for the production of magnetic tapes, abrasives, tiles, glass, cosmetics and pigments).

Since the fluidized bed process operates at approximately 850°C, rinse and scrubber water from the pickle line can be used at the regeneration plant to cool fluidized bed off-gases, which contain hydrochloric acid vapor and a small amount of iron oxide dust. The off-gases are cooled to approximately 100°C in a venturi scrubber. The thermal energy of the off-gases is used to concentrate the pickling liquor by evaporation before it is fed to the reactor. From the venturi scrubber, the cooled gas stream goes to the absorber, where hydrogen chloride is absorbed with rinse water from the pickling line and fresh water to produce hydrochloric acid. The acid can be recycled directly to the pickling process or placed in a storage tank for later use. Once the fluidized bed off-gases have passed through the scrubbing stages and mist collector, the off-gases are virtually free of hydrochloric acid and are released to the atmosphere.

- *Sulfuric Acid Recovery.* To recover sulfuric acid, spent pickle liquor high in iron content is pumped into a crystallizer, where the iron is precipitated (under refrigeration or vacuum) as ferrous sulfate heptahydrate crystals. As the crystals are formed, water is removed with the crystals, and the free acid content of the solution increases to a level that is useable in the pickling operation. The crystals are separated from solution, and the recovered acid is pumped back into the pickling tank. The by-product ferrous sulfate heptahydrate is commercially marketable. The crystals are dried, bagged, and marketed, or sold in bulk quantities. Ferrous sulfate, commonly referred to as "copperas," is used in appreciable quantities in numerous industries, including the manufacture of inks, dyes, paints, fertilizers, and magnetic tapes. It is also used as a coagulant in water and wastewater treatment (Reference 8-3).

- *Acid Purification and Recycle.* Acid purification technology is applicable to various acid pickling solutions, such as sulfuric acid, and nitric/hydrofluoric acids used in stainless steel finishing mills. Acid is purified by adsorption on a bed of alkaline anion exchange resin that separates the acid from the metal ions. Acid is desorbed from the resin using water. The process begins by passing spent acid upward through the resin. A metal-rich, mildly acidic solution passes through the resin and is collected at the top of the bed. Water is then pumped downward through the bed and desorbs the acid from the resin. The purified acid solution is collected at the bottom of the bed. This technology can recover approximately 80 percent of the free acid remaining in a spent acid treatment solution.

- *Nitric-Acid-Free Pickling.* Nitrates were identified as a pollutant of concern for stainless steel acid pickling operations where nitric acids and combinations of nitric and hydrofluoric acids are used for surface treatments for various grades of stainless steels. When consumed in

drinking water, nitrates may cause health problems in humans, particularly infants. The Agency is considering regulating nitrates/nitrites and is investigating in-process treatment alternatives to eliminate nitrate discharges. The Agency is aware of a proprietary commercial technology that uses a nitric acid free solution that contains an inorganic mineral acid base, hydrogen peroxide, stabilizing agents, wetting agents, brighteners, and inhibitors. This process requires the same equipment as conventional acid pickling processes, with the addition of agitation to the bath to circulate fresh acid to the metal surface. The process is also compatible with acid regeneration. Acid purification and recycle, discussed above, is also an in-process treatment technology that can reduce nitrate discharges significantly.

- *Effluent-Free Exhaust Cleaning for Stainless Steel Pickling.* Stainless steel pickling operations using mixed acid, nitric acid, or hydrofluoric acid produce exhaust gases that contain nitrogen oxide and hydrogen fluoride. WAPCs are typically used to treat these exhaust gases, thereby generating wastewater. The Agency is aware of a commercially available technology that uses selective catalytic reduction (SCR) technology to treat exhaust gases from stainless steel pickling operations in lieu of WAPCs (Reference 8-5).

- *In-Tank Filtration.* Paper, cloth, or plastic filters are used to extend process bath life through removal of accumulated suspended solids or precipitant. Dissolved contaminants, such as organic constituents, are removed through devices such as granular activated carbon filters.

- *Magnetic Separation of Fines in Cold Rolling Solution.* Magnetic separators are sometimes used in the iron and steel industry to extend the life of cold rolling solutions. Magnetic separators are either installed in rolling solution collection tanks or in a side-stream system connected to these tanks. The most effective systems use vertical or horizontal configurations of magnetic rods to remove fines. Well-designed magnetic separators can control the iron content in the rolling solutions to below 100 parts per million (Reference 8-6).

- *Ion Exchange.* Ion exchange is a reversible chemical reaction that exchanges ions in a feed stream for ions of like charge on the surface of an ion-exchange resin. Resins are broadly divided into cationic or anionic types. Typical cation resins exchange H^+ for other cations, while anion resins exchange OH^- for other anions. Many types of process wastewater are excellent candidates for ion exchange, including the rinse water from plating processes of lead, nickel, tin, tin-lead, chromium, and zinc.

Ion exchange can be used for both water recycling and/or metal recovery. For water recycling, cation and anion columns are placed in series. The feed stream is deionized and the product water is reused for rinsing. The regenerant from the cation column typically contains metal species (with the exception of chromium, which is captured in the anion column), which can be recovered in elemental form via recovery. The anion regenerant is typically discharged to wastewater treatment. When metal recovery is the only objective, a single or double cation column unit containing selective resin is used. These resins attract divalent cations while allowing monovalent cations to pass, a process usually referred to as metal scavenging. Water cannot be recycled because contaminants other than the target cations remain in the stream exiting the column.

Ion exchange equipment ranges from small, manual, single-column units to multi-column, highly automated units. For continuous service, two sets of columns are necessary. One set handles the service flow, and the other set is regenerated. Thus, two-column metal scavenging and four-column deionizing systems are common. Automatic systems direct the wastewater flow and initiate regeneration with little or no operator interaction. Equipment size is based on flow volume and concentration. Resin capacity varies but often ranges from 1 to 2 pounds per cubed feet. Columns are typically sized to handle wastewater flow for at least a period of time equal to the time required for regeneration. Automatic systems are sized to provide continuous service. Regeneration volume typically ranges from 2 to 4 resin bed volumes of dilute acid or caustic.

- ***Evaporation with Condensate Recovery.*** Evaporation is a common chemical recovery technology. There are two basic types of evaporators: atmospheric and vacuum. Atmospheric evaporators, the more prevalent type, are relatively inexpensive to purchase and easy to operate. Vacuum evaporators are mechanically more sophisticated and are more energy-efficient. Vacuum evaporators are typically used when evaporation rates greater than 50 to 70 gallons per hour are required. Additionally, with vacuum evaporators, evaporated water can be recovered as a condensate and reused on site.

  A disadvantage of evaporation-based recovery is that all drag-out, including unwanted contaminants, are returned and accumulate in the process bath. For this reason, deionized water is preferred as rinse water to prevent the introduction of water contaminants in the process bath.

- ***Best Management Practices.*** There are many plant maintenance and good housekeeping management practices that can be applied at all iron and steel facilities: training and supervision, production planning and sequencing, process or equipment modification, raw material and product substitution

or elimination, and loss prevention and housekeeping (Reference 8-7). These alternatives are discussed below:

—   <u>Training and Supervision</u>. Training and supervision ensures that employees are aware of, understand, and support the company's waste minimization goals. These goals are translated into practical information that will enable employees to minimize waste generation through the proper and efficient use of tools, supplies, equipment, and materials.

—   <u>Production Planning and Sequencing</u>. Production can be planned to minimize the number of steps and eliminate unnecessary procedures (e.g., plan production to eliminate additional cleaning steps between incompatible operations).

—   <u>Process or Equipment Modification</u>. Processes and equipment can be modified to minimize the amount of waste generated (e.g., reducing drag-out by slowing the withdrawal speed of part, installing electrolytic recovery units).

—   <u>Raw Material and Product Substitution or Elimination</u>. Where possible, raw materials or products should be replaced with other materials that produce either less waste and/or less toxic waste (e.g., replacing chromium-bearing solutions with non-chromium-bearing and less toxic solutions, consolidating types of cleaning solutions and machining coolants).

—   <u>Oil Management and Preventive Maintenance</u>. Where possible, sites should remove oil in recycle treatment, recycle used oil, and ensure integrity of process area containment systems.

—   <u>Loss Prevention and Housekeeping</u>. Loss prevention and housekeeping includes performing preventive maintenance and managing equipment and materials to minimize leaks, spills, evaporative losses, and other releases (e.g., inspecting the integrity of tanks on a regular basis, using chemical analyses instead of elapsed time or amount of product processed as the basis for disposal of a solution). Solution testing is one important loss prevention alternative. The chemical make-up of cleaning solutions changes over time due to evaporative losses, additions of water, drag-out of cleaning chemicals, consumption of bath chemistry, chemical reactions, and drag-in of impurities. Because of these factors, cleaning baths lose strength, performance declines, and solutions require disposal. Many sites operate cleaning baths with a schedule consisting of three steps: formulate, use, and discard.

This procedure can be expensive and inefficient from a production standpoint, and creates large volumes of waste. For this reason, sites should frequently determine the strength of the cleaning solution and appropriate chemical additions needed to continue solution use. By implementing a program of testing and record keeping, sites can reduce the disposal frequency of cleaning baths.

— <u>Waste Segregation and Separation</u>. Mixing different types of wastes or mixing hazardous wastes with nonhazardous wastes should be avoided. Recyclable materials should not be mixed with incompatible materials or wastes. For example, hexavalent-chromium-bearing wastewater can be separated for preliminary treatment.

Other in-process treatment technologies that could be applied to pickling and electroplating wastewater generated by the steel finishing industry include electrowinning and reverse osmosis. Electrowinning can recover metals from ion exchange regenerants and return the metals to the plating bath. Reverse osmosis is a membrane technology that can be used to recover metal salts and generate a treated water stream that can be recycled for use as a rinse water. Neither of these technologies were reported in industry survey responses as a metals recovery technology; however, these technologies are commonly used in similar electroplating operations and are therefore applicable to the iron and steel finishing industry (Reference 8-8). For more information on these processes and other potentially applicable in-process treatment technologies, refer to the <u>Development Document for the Proposed Effluent Limitations Guidelines and Standards for the Metals Products and Machinery Point Source Category</u> (Reference 8-8).

8.1.2　End-of-Pipe Treatment Technologies

The following subsections discuss the various end-of-pipe wastewater treatment technologies applicable to iron and steel facilities.

- Flow equalization;
- Cooling technologies;
- Coke plant treatment technologies;
- Cyanide treatment technologies;
- Oily wastewater treatment technologies;
- Metals treatment technologies;
- Solids handling technologies; and
- Polishing technologies.

Table 8-2 summarizes the end-of-pipe wastewater treatment and disposal technologies for all of these subsections.

Flow Equalization

Flow equalization is a critical treatment component to achieve consistent wastewater treatment performance for end-of-pipe treatment systems at all iron and steel facilities. Flow equalization before ammonia distillation and biological treatment at by-product recovery cokemaking facilities, and before chemical precipitation and clarification systems at integrated, non-integrated, and stand-alone facilities dampen fluctuations (reduce variability) in flow and influent wastewater quality. For by-product recovery cokemaking, flow equalization can also eliminate shock loadings of inhibitory substances to the biological treatment system. The effluent quality and thickening performance of secondary clarifiers following biological treatment is also improved as a result of constant solids loadings. Flow equalization improves the performance of chemical precipitation systems as a result of improved chemical feed control and process reliability. Eliminating rapid flow increases to gravity clarification equipment lessens the chance of disrupting the sludge bed. For multimedia filtration systems, flow equalization results in a constant media filtration surface area requirement and more uniform filter-backwash cycles.

The key design parameter for flow equalization is the required tank volume. Another key component of the equalization tank system is mixing. Two types of mixing are typically observed in equalization systems: conventional top or side-mount impeller mixers and a pump system that continuously removes a portion of the wastewater from the tank and reintroduces it into the untreated wastewater flow.

Cooling Technologies

Cooling technologies are used to attain water temperatures appropriate to facilitate end-of-pipe treatment and for reuse in high-rate recycle systems. Cooling is used in recirculation systems for blast furnace, vacuum degassing, continuous casting, and hot forming operations. Cooling is also commonly used prior to biological treatment systems at by-product recovery cokemaking plants to prevent water temperatures detrimental to biomass.

- *Cooling Towers.* Counterflow induced draft cooling towers are common in the iron and steel industry. The counterflow arrangement is superior to the cross-flow tower for greater cooling ranges (Reference 8-9). Performance of a given cooling tower is governed by the ratio of the weights of air to water and the time of contact between water and air. The time of contact between water and air is governed largely by the time required for the water to discharge from the nozzles and fall through the tower to the basin. The time of contact is therefore obtained in a given type of unit by varying the height of the tower.

- *Shell-and-Tube Heat Exchangers.* This is an indirect contact device that facilitates the transfer of heat from one fluid stream to another. Counterflow, shell-and-tube heat exchangers are common in the iron and steel industry. Liquid to be cooled or heated is pumped through tubes that run the length of the shell of the heat exchanger while another liquid to be

cooled or heated is pumped through the shell and passes over the tubes. Baffles placed along the shell direct the flow in the shell over the tubes to promote turbulence and support tubes in horizontal units.

### Coke Plant Treatment Technologies

By-product recovery cokemaking operations produce wastewater containing nutrients such as ammonia and dissolved organic matter, including phenols, volatile organic compounds (VOCs), and polyaromatic hydrocarbons (PAHs), which if discharged untreated can result in growth of microbial populations and vegetation that deplete the oxygen concentration of the receiving stream to levels which can not support aquatic organisms. In the cokemaking industry, tar filtration, ammonia distillation, and biological treatment systems can be used to remove nutrients and dissolved organic matter from wastewater. Each of these types of treatment systems is described below.

- *Tar Removal.* Tar decanters are used to recover oil and tar from excess ammonia liquor generated during cokemaking. A mechanical filter can be placed on the tar decanter effluent to prevent residual tar and oil from entering the ammonia distillation system. The multiple tube filter uses a filter element made from porous aluminum oxide ceramic that can remove particulate as fine as 0.3 microns with flow rates of approximately 2 gallons per minute per square foot (gal/min/ft^2). At the end of each filtration cycle, collected solids are removed from the filter by backwashing. Removing the large-chained organic compounds present in tar significantly reduces the carbonaceous biochemical oxygen demand (CBOD$_5$) of cokemaking wastewater.

- *Free and Fixed Ammonia Distillation (Stripping).* Ammonia stripping is the transfer of gas (ammonia) dissolved in a liquid (waste ammonia liquor) into a gas stream (steam). In the cokemaking industry, flushing liquor is pumped to the top of a tray-type distillation tower and steam is injected into the base. As the rising steam passes through the boiling ammonia liquor moving down the tray tower, ammonia is transferred from the liquid to the gas phase, eventually passing out the top of the tower. The hot, ammonia-rich steam is collected, cooled, and typically treated with sulfuric acid to form ammonium sulfate, a by-product that can be shipped off site for use as a fertilizer. Liquid collected from the bottom of the stripping tower is cooled and transferred to a holding tank prior to further on-site treatment to remove any residual ammonia, or before discharge to the publicly owned treatment works (POTW).

  The efficiency of the stripping tower is a related to the number of trays (transfer units) that the liquid must pass over before reaching the bottom. Therefore, the higher the tower, the more trays and greater ammonia removal efficiency. The tower diameter is a function of the flow rate to the

system. Ammonia stripping towers in the cokemaking industry typically range in height from 30 feet to over 100 feet, with diameters ranging between 4 and 8 feet.

•   ***Biological Nitrification.*** Biological nitrification is the aerobic process of converting ammonia to nitrate in a conventional activated sludge system configured with an aeration tank, a clarifier, and return sludge equipment. Figure 8-1 presents a process flow diagram of a typical biological nitrification system. Diffused or mechanical aeration achieve the aerobic environment in the reactor and also serves to maintain the mixed liquor in a completely mixed regime. After a specified period of time, the mixture of new bacterial cells and old bacterial cells passes into a settling tank where the cells are separated from the treated wastewater. A portion of the settled cells is recycled to maintain the desired concentration of organisms in the reactor, and a portion is wasted. In the activated sludge nitrification process, the ammonium ion is converted to nitrate in two steps by autotrophic bacteria, as summarized by the following reactions (Reference 8-10):

$$NH_4^+ + 3/2\ O_2 \longrightarrow NO_2^- + 2H^+ + H_2O \tag{8-5}$$

$$NO_2^- + 1/2\ O_2 \longrightarrow NO_3^- \tag{8-6}$$
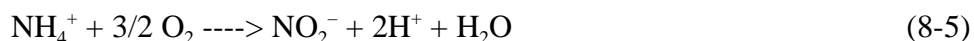
In addition to obtaining energy from the reaction shown above, the bacteria assimilates a portion of the nitrogen into the cell tissue as shown by the following reaction:

$$4CO_2 + HCO_3^- + NH_4^+ + H_2O \longrightarrow C_5H_7NO_2 + 5O_2 \tag{8-7}$$
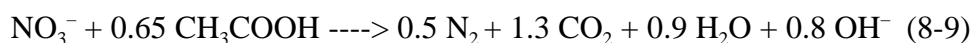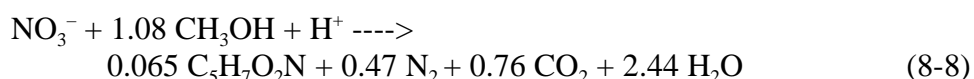
As shown in Equation 8-7, the nitrifying autotrophic bacteria use carbon dioxide and bicarbonate as a carbon source. The most important factor in controlling the nitrification system is the sludge retention time (SRT). Other significant factors on affecting nitrification include hydraulic retention time (HRT), ammonia and nitrite concentrations, the BOD_5/TKN ratio, dissolved oxygen concentration, temperature, and pH.

•   ***Biological Denitrification.*** Biological denitrification (anaerobic) is applicable to the treatment of cokemaking wastewater following biological nitrification. Denitrification is a metabolic process in which nitrate is converted to nitrogen gas in the presence of a combined hydrogen source and a lack of free oxygen. The bacteria that are able to reduce nitrate are facultative heterotrophs of the genera Pseudomonas, Micrococcus, Achromobacter, and Bacillus (Reference 8-11). The reaction involves the transfer of electrons from organic carbon (oxidation) to nitrate (reduction) promoting its conversion to nitrogen gas. The biochemical pathway in

which nitrate is substituted for oxygen as the final electron acceptor in the electron transport chain is thermodynamically less favorable than if oxygen were the final electron acceptor. In the presence of free oxygen, denitrification ceases and typical aerobic oxidation predominates. Denitrification is typically referred to as anoxic respiration since it is an aerobic process in the absence of free oxygen.

The anoxic process, like the aerobic process, utilizes organic carbon to maintain cellular respiration and synthesis of biomass. The carbon can be derived from either the endogenous decay of biomass or from an external source, such as added methanol or organic materials already in the waste. The majority of denitrification systems operating in the United States use methanol as their carbon source. The equations below show the balanced stoichiometric reactions for the conversion of nitrate to nitrogen gas with either methanol (Equation 8-8) or acetic acid (Equation 8-9) as the carbon source (Reference 8-10).

$$NO_3^- + 1.08\ CH_3OH + H^+ \longrightarrow$$
$$0.065\ C_5H_7O_2N + 0.47\ N_2 + 0.76\ CO_2 + 2.44\ H_2O \tag{8-8}$$

$$NO_3^- + 0.65\ CH_3COOH \longrightarrow 0.5\ N_2 + 1.3\ CO_2 + 0.9\ H_2O + 0.8\ OH^- \tag{8-9}$$

For denitrification of cokemaking wastewater, two treatment options are applicable: 1) a unit in which all the flow from the biological nitrification system enters the denitrification system; or 2) a recycle system in which a portion of the effluent from the biological nitrification system is returned to the beginning of the treatment system and mixed with fresh wastewater. Figure 8-2 presents denitrification systems. For the end-of-pipe denitrification system, a supplemental carbon source such as methanol would be required to convert nitrate to nitrogen gas. For the recycle system, recycle equipment and tanks would be required to handle recycle volumes approximately 3 to 4 times the original wastewater flow.

Cyanide Treatment Technologies

Cyanide is present in process wastewater from by-product recovery cokemaking, blast furnace, and sintering operations. In biological treatment, many microorganisms can acclimate to relatively high concentrations of cyanides and have been documented to successfully treat wastewaters with concentrations up to 30 mg/L (Reference 8-12). The following treatment options are applicable to by-product recovery cokemaking (as add-ons to biological treatment), blast furnace ironmaking, and sintering wastewater for cyanide removal.

• *Cyanide Precipitation.* Cyanide precipitation combines cyanide in the waste ammonia liquor from cokemaking with iron to form an insoluble
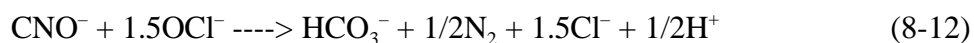
iron-cyanide complex that can be precipitated and removed by gravity settling. The process can be illustrated by the following chemical reaction:

$$3CN^- + Fe^{+3} ----> FeCN_3 \tag{8-10}$$

Excess iron is typically added in the form of ferric sulfate ($Fe_2(SO_4)_3$) and the pH is adjusted to approximately 4.5 using sulfuric acid. Following complex formation, polymer is added to flocculate the iron-cyanide particulates, allowing them to settle in a gravity clarifier. Effluent from the gravity clarifier can be pH adjusted to neutral prior to discharge, or the pH can be raised to approximately 9 to precipitate any residual metals.

- *Alkaline Chlorination.* Alkaline chlorination can be applied to both cokemaking and blast furnace ironmaking wastewater for the destruction of cyanide, phenolics, and ammonia. An alkaline chlorination unit uses sodium hypochlorite or chlorine gas in a carefully controlled pH environment to remove cyanide and ammonia. The process oxidizes cyanide to bicarbonate and nitrogen gas, and ammonia to nitrogen gas and water, as illustrated by the following chemical reactions (Reference 8-12):

Cyanide:

$$CN^- + OCl^- ----> CNO^- + Cl^- \tag{8-11}$$

$$CNO^- + 1.5OCl^- ----> HCO_3^- + 1/2N_2 + 1.5Cl^- + 1/2H^+ \tag{8-12}$$

Ammonia:

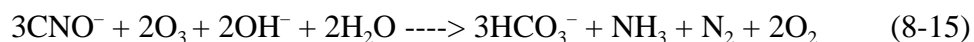$$2NH_4^+ + 3HOCl ----> N_2 + 3H_2O + 3HCl + 2H^+ \tag{8-13}$$

The alkaline chlorination process oxidizes cyanides to carbon dioxide and nitrogen, and ammonia to nitrogen and hydrochloric acid. The equipment consists of two reaction tanks, each with an agitator and a pH and oxidation-reduction potential (ORP) controller. The first step (tank 1) of the reaction oxidizes cyanides to cyanate. To affect the reaction, sodium hypochlorite is metered into the reaction tank as necessary to maintain the ORP at 350 to 400 millivolts, and aqueous sodium hydroxide is added to maintain a pH of 10 to 11. In the second step (tank 2), the ORP and the pH level are maintained at 600 millivolts and 8 to 9, respectively, to oxidize cyanate to carbon dioxide and nitrogen. Each step has an agitator designed to provide approximately one turnover per minute.

Alkaline chlorination can be performed at ambient temperature and automatically controlled and is capable of achieving effluent levels of cyanide that are below detection. However, the reaction must occur at

carefully controlled pH levels and has the possibility of chemical interferences when treating mixed wastes. The effectiveness of the unit depends on the pretreatment and segregation of cyanide waste streams and the careful control of the pH. The size and type of system is solely dependent on the cyanide waste stream flow volume. Another disadvantage is that oxidation of organic compounds using chlorine has the potential to form trihalomethanes.

- ***Ozone Oxidation.*** Another less common cyanide treatment method is ozone oxidation. Ozone gas is bubbled through a wastewater solution containing cyanide. A portion of the ozone in the gas phase is transferred to the liquid where it reacts with cyanide, converting it to cyanate. Additional ozone reacts with the cyanate for complete conversion to nitrogen gas, ammonia, and bicarbonate as shown by the reaction below:

$$CN^- + O_3 \longrightarrow CNO^- + O_2 \tag{8-14}$$

$$3CNO^- + 2O_3 + 2OH^- + 2H_2O \longrightarrow 3HCO_3^- + NH_3 + N_2 + 2O_2 \tag{8-15}$$

The reaction rate is limited by mass-transfer of ozone to the liquid, the cyanide concentration, and temperature (Reference 8-13). Ozone is not effective in treating metallocyanide complexes, such as ferrocyanide, unless ultraviolet light is added to the reaction vessel.

One advantage of ozone over chlorine is the type of residuals formed. Oxidation of organic compounds using chlorine has the potential to form trihalomethanes, which are suspected carcinogens. Ozone oxidation of organic compounds forms short chained organic acids, ketones, and aldehydes instead. Equipment required for ozone oxidation of cyanides includes an ozone generator, gas diffusion system, a mixed reaction tank, and off-gas controls to prevent the release of unreacted ozone. The major disadvantages of the ozone oxidation process are the operating costs and the capital costs of the ozone generating and transfer equipment and off-gas control system.

Oily Wastewater Treatment Technologies

Hot forming and cold rolling operation wastewaters contain high levels of O&G. For hot forming operations, scale pits and roughing clarifiers fitted with oil skimmers remove nonemulsified O&G from high-rate recycle systems. Section 8.1.1 discusses these technologies. Oily wastewater generated by cold rolling operations contain some emulsified oils that require chemical treatment prior to removal. The following describes technologies that can be used to remove both emulsified and nonemulsified oils.

- ***Oil Removal by Gravity Flotation.*** O&G present in iron and steel wastewater can either be emulsified or nonemulsified. The characteristics of emulsified oils vary widely, depending on the types of oils used in the process. If wastewater contains emulsified oils, chemical treatment is required to separate the oils from solution prior to other treatment steps. Oil skimming can be used for nonemulsified oil treatment. The wastewater is discharged through a tank or basin of sufficient size and design to allow the oil to separate and rise to the surface. At the surface, the oil is contained by the underflow baffles and skimmed. Common separation devices that can be used for separation of nonemulsified oils include American Petroleum Institute (API) separators, disk, belt, and rotating drum oil skimmers, and coalescers.

  Skimming is a simple method for separating floating oil from cleaning solutions. Skimming devices are typically mounted onto the side of a tank and operate on a continuous basis. The disk skimmer consists of a vertically rotating disk (typically 12 to 24 inches in diameter) that is partially submerged into the liquid of a tank (typically to a depth of 4 to 12 inches below the liquid surface). The disk continuously revolves between spring loaded wiper blades that are located above the liquid surface. The adhesive characteristics of the floating oil cause the oil to adhere to the disk. The oil is removed from the disk as the disk surface passes through the wiper blades and is diverted to a run-off spout for collection. Maximum skimming rates are typically in the range of 2 to 10 gallons per hour of oil. Belt and drum skimmers operate in a similar manner, with either a continuous belt or drum rotating partially submerged in a tank. As the surface of the belt or drum emerge from the liquid, the oil that adheres to its surface is scraped (drum) or squeezed (belt) off and diverted to a collection vessel.

  Coalescers are typically designed as tanks containing a coalescing media that accelerates phase separation. Cleaning solution and oil are removed from the process tank by a suction skimmer and pumped to the coalescer. The media in the coalescers is a material such as polypropylene, ceramic, or glass which attracts oil in preference to water (i.e., oleophilic). The oil/cleaner mixture passes through the unit and the oil adheres to the coalescing media. The oil forms droplets that conglomerate and rise to the surface of the tank where the oil is removed by a skimming device or weir (Reference 8-14).

- ***API Oil/Water Separators.*** The API oil/water separator is typically a rectangular basin, designed with baffles to trap sediments and retain floating oils, that can achieve 150-micron droplet oil removal as per API standards. This separator is used for wastewater containing oil with heavy solids content or when long retention times are required. Standard

configurations of these systems include surface oil skimmers, sloped bottoms, and augers to remove collected sludge.

• *Oil Removal by Emulsion Breaking and Dissolved Air Flotation.* If wastewater contains emulsified oils, chemical treatment is required to separate the oils from solution prior to other treatment steps. Chemical treatment is used to break stable oil/water emulsions (oil dispersed in water, stabilized by electrical charges and emulsifying agents). A stable emulsion will not separate without chemical treatment. Chemical emulsion breaking is applicable to wastewater streams containing emulsified coolants and lubricants. This technology is also applicable to cleaning solutions that contain emulsified oils.

The major equipment required for chemical emulsion breaking includes reaction chambers with agitators, chemical storage tanks, chemical feed systems, pumps, and piping. Factors to be considered for destroying emulsions are type of chemicals, dosage and sequence of addition, pH, mixing, heating requirements, and retention time. Chemicals (e.g., polymers, alum, ferric chloride, and organic emulsion breakers) destroy emulsions by neutralizing repulsive charges between particles, precipitating or salting out emulsifying agents, or weakening the interfacial film between the oil and water so it is readily broken. Reactive cations (e.g., H^+, Al^{+3}, Fe^{+3}) and cationic polymers are particularly effective in destroying dilute oil/water emulsions. Once the charges have been neutralized or the interfacial film broken, the small oil droplets and suspended solids either adsorb on the surface of the floc that is formed or break out and float to the top. Different types of emulsion-breaking chemicals are used for different types of oils. If more than one chemical is required, the sequence of addition can affect both breaking efficiency and chemical dosages.

Solid wastes generated by chemical emulsion breaking include surface oil and oily sludge, which are usually contract hauled for disposal by a licensed contractor. If the recovered oil has a sufficiently low percentage of water, the oil may be burned for its fuel value or processed and reused.

Dissolved air flotation combined with chemical emulsion breaking is an effective method of oil removal. With dissolved air flotation, air is injected into a fluid under pressure. The amount of air that can dissolve in a fluid increases with increasing pressure. When the pressure is released, the air comes out of solution as bubbles that attach to O&G particles, thus "floating" the O&G to the surface. There are two types of operational modes for dissolved air flotation systems, full flow pressurization and recycle pressurization. In full flow pressurization, all influent wastewater is pressurized and injected with air. The wastewater then enters the flotation unit where the pressure is relieved and bubbles form causing the O&G to

rise to the surface. In a recycle pressurization system, part of the clarified effluent is recycled back to the influent of the dissolved air flotation unit, then pressurized and supersaturated with air. The recycled effluent then flows through a pressure release valve to the flotation unit.

- ***Oil Removal by Ultrafiltration.*** Ultrafiltration is a pressure-driven membrane process that separates emulsified oils without the need for chemical emulsion breaking. Using an applied pressure difference across a membrane, solvent and small solute species pass through the membrane and are collected as permeate while larger compounds are retained by the membrane and are recovered as concentrate.

  Ultrafiltration is used to remove materials ranging from 0.002 to 0.2-microns or molecular-weights from 500 to 1,000,000 (e.g. oil emulsion and colloidal silica) (Reference 8-15). Prefiltration of the ultrafiltration influent is advisable to remove large particles and free oil to prevent membrane damage and membrane fouling. Many ultrafiltration membranes are typically made of homogeneous polymer or copolymer material. The transmembrane pressure required for ultrafiltration typically ranges between 15 to 200 pounds per square inch and is dependant on membrane pore size.

  Ultrafiltration results in a concentrated oil phase that is 2 to 5 percent of the influent volume (Reference 8-8). Oily concentrates are typically contract hauled or incinerated and the permeate (water phase) can either be treated further to remove water soluble metals and organic constituents or be directly discharged, depending on local and state requirements.

  The ultrafiltration system includes a number of components such as pumps and feed vessels, piping or tubing, monitoring and control units for temperature, pressure and flow rate, process and cleaning tanks, and membranes. Membranes are specifically designed to handle various waste stream parameters, including temperature, pH, and chemical compatibility. Membranes can be purchased in several different configurations, including hollow fiber, tubular, flat plate, and spiral wound (Reference 8-15). The configuration selected for each application is dependent on the type of application. For example, tubular membranes are commonly used to separate suspended solids, whereas spiral wound membranes are used to separate oil from water. The spiral wound design ultrafiltration membranes have a high membrane packing density and effective mass transfer characteristics.

Metals Treatment Technologies

Dissolved and total metals are present in high-rate recycle system blowdown wastewater from blast furnace, sintering, basic oxygen furnace (BOF), vacuum degassing, and continuous casting operations at levels that require treatment before discharge. Pickling, electroplating, and other steel finishing processes also generate wastewater containing dissolved and total metals. If left untreated, metals can accumulate in the environment to levels which become toxic to humans, terrestrial and aquatic organisms, and plants.

Chemical precipitation followed by gravity sedimentation is the treatment technology most commonly used by the industry to remove dissolved and total metals from wastewater. Hexavalent chromium reduction is used as a pretreatment step prior to hydroxide precipitation for hexavalent-chromium-bearing wastewater generated in steel finishing. The following discusses hexavalent chromium reduction, chemical precipitation, and solids removal technologies, including gravity clarification and membrane separation.

- ***Hexavalent Chromium Reduction.*** Reduction is a chemical reaction in which electrons are transferred from one chemical (the reducing agent) to the chemical being reduced. Sulfur dioxide, sodium bisulfite, sodium metabisulfite, and ferrous sulfate form strong reducing agents in water. They are used at iron and steel finishing sites to reduce hexavalent chromium to the trivalent form, which allows the metal to be removed from solution by chemical precipitation. The reaction in these processes is illustrated for the following sulfur dioxide reaction (reduction using other reagents is chemically similar):

  $$2H_2CrO_4 + 3SO_2 \longrightarrow Cr_2(SO_4)_3 + 2H_2O \qquad\qquad (8\text{-}16)$$
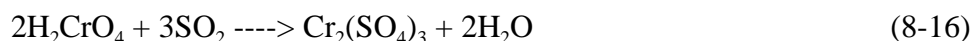
  An operating pH level between 2 and 3 is normal. At pH levels above 5, the reduction rate is slow and oxidizing agents such as dissolved oxygen and ferric iron interfere with the reduction process by consuming the reducing agent.

  A typical treatment involves retention in a reaction tank for 45 minutes. The reaction tank is equipped with pH and ORP controls. Sulfuric acid is added to maintain a pH of approximately 2.0, and a reducing agent is metered to the reaction tank to maintain the ORP at 250 to 300 millivolts. The reaction tank is equipped with an impeller designed to provide approximately one bath volume per minute.

  Chemical reduction of hexavalent chromium is a proven technology that is widely used at iron and steel finishing sites. Operation at ambient conditions requires little energy and the process is well suited to automatic control.

- ***Chemical Precipitation.*** Chemical precipitation involves the removal of metallic contaminants from aqueous solutions by converting soluble, heavy metals to insoluble salts. The precipitated solids are then removed from solution by flocculation followed by sedimentation and/or filtration. Precipitation is caused by the addition of chemical reagents that adjust the pH of the water to the minimum solubility of the metal. The standard reagents include the following:

  — Lime (calcium hydroxide);
  — Caustic (sodium hydroxide);
  — Magnesium hydroxide;
  — Soda ash (sodium carbonate);
  — Trisodium phosphate;
  — Sodium sulfide; and
  — Ferrous sulfide.

  These reagents precipitate metals as hydroxides, carbonates, phosphates, and sulfides. Metals commonly removed from solution by precipitation include arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc.

  Figure 8-3 presents a flow diagram of the typical precipitation process for metals removal. A chemical precipitant is added to the metal containing water in a stirred reaction vessel. The dissolved metals are converted to an insoluble form by a chemical reaction between the soluble metal and the precipitant. The suspended particles are then flocculated and either settled in the batch tank or passed to a membrane filter. Granular media filtration can be used to polish any suspended metal precipitates that do not settle in the reaction tank.

  Hydroxide precipitation is the prevalent type of chemical precipitation. Hydroxide precipitation normally involves the use of calcium hydroxide (lime), sodium hydroxide (caustic), or magnesium hydroxide as a precipitant to remove metals as insoluble metal hydroxides. The reaction is illustrated by the following equation for precipitation of a divalent metal using sodium hydroxide:

  $$M^{++} + 2NaOH \longrightarrow M(OH)_2 + 2Na^+ \tag{8-17}$$

  The effluent metals concentration attained by hydroxide precipitation is dependent on the metals present, precipitant used, the reaction conditions, especially pH, and the presence of other materials that may inhibit precipitation. Effluent metals concentrations of less than 1 mg/L, and sometimes less than 0.1 mg/L, are achievable by hydroxide precipitation.

The solubility of the metal is directly related to the pH of its environment. Many metals can form low solubility hydroxides in the pH range of 8.5 to 11.5. However, several metallic compounds are amphoteric and exhibit a rigid point of minimum solubility. Any further addition of alkali can drastically increase the solubility of the compound. Different metals have various minimum solubility points, which can pose a challenge when aqueous waste streams have highly variable metal compositions. Figure 8-4 shows the minimum solubilities of some common metals at various pH values.

The solubility curves in Figure 8-4 indicate achieving the minimum solubility of all metals at a single operating pH would be difficult. At a pH at which the solubility of one metal hydroxide may be minimized, the solubility of another may be relatively high. In the majority of cases, a pH between 9 and 11, selected on the basis of jar tests or operating experience with the water, produces an acceptable effluent quality. For a waste containing several metals, however, more than one precipitation stage with different pH control points may be required to remove all the metals of concern to the desired level.

Removal of precipitated metals typically involves the addition of flocculating agents or polymers to destabilize the hydrodynamic forces that hold the particle in suspension. For a continuous system, polymer is normally added in-line between the reaction tank and the flocculation tank. In the flocculation tank, the mixer is slowed to promote agglomeration of the particles until their density is greater than water and they settle from solution in the clarifier.

- *Clarification.* Gravity sedimentation to remove solids is a common method of clarification used in recycle and end-of-pipe systems within the iron and steel industry. High-efficiency clarifiers are used for end-of-pipe treatment and ironmaking and integrated steelmaking recycle systems that do not require water quality equivalent to filtered effluent for reuse in manufacturing processes. In continuous casting and hot forming recycle systems, it is good practice to pump contact cooling waters that collect in scale pits to a roughing clarifier for coarse solids removal prior to filtration, cooling, and recirculation. To improve the performance of high-efficiency and roughing clarifiers, coagulants such as polymers are added. These coagulant aids enhance solids removal by aiding in the formation of larger, more readily settleable particles. Two important design parameters for roughing and high-efficiency clarifiers include both the surface area of the clarifier and the detention time. Like high-efficiency clarifiers, roughing clarifiers are normally designed on the basis of a surface-loading rate expressed as gallons per day per square foot of surface area (gal/day/ft^2) and provide 90 to 150 minutes of detention based on the average flow rate

(Reference 8-9). The surface-loading rate depends on the type of material to be separated. The table below shows the range of surface loading rates for high-efficiency clarifiers (Reference 8-11).

Suspension	Range gal/day/ft^2	Peak Flow gal/day/ft^2
Activated sludge solids	590 - 785	1,460
Alum floc	613 - 1,200	1,200
Iron floc	613 - 1,200	1,200
Lime floc	730 - 1,460	1,460
Untreated wastewater	613-1,200	1,200

However, unlike more efficient clarifiers, roughing clarifiers are designed to remove large solids that rapidly settle. Therefore, surface loading rates may be three to four times those observed for high-efficiency clarifiers presented in the table. When the area of the tank has been established, the detention period in the tank is governed by the water depth. Open-top circular or rectangular shaped clarifiers are typically used for sedimentation of biological treatment solids from nitrification in the cokemaking industry.

For sedimentation of iron-cyanide solids from the treatment of cokemaking wastewater, inclined tube or lamella clarifiers are commonly used. Depending on land availability and wastewater flow rates, open-top, inclined tube, or lamella clarifiers are used for sedimentation of metal hydroxides generated from treatment of ironmaking, steelmaking, and steel finishing wastewater. The inclined tubes in the clarifier are oriented at angles varying between 45 and 60 degrees from the horizontal plane. Although the tube may be shaped in many forms, rectangular or square shapes are more common. Water enters the tank and solids settle to the tank bottom. As the water continues upward through the tubes, additional solids settle on the lower side of the tube. The clarified effluent continues up through the tube and passes over the weir. The solids collect and agglomerate on the lower side of the tube and because of the tube inclination, slide downward through the tube. They then drop back into the settling tank, where they collect on the bottom, and are scraped away into a sludge hopper before discharge to the thickener. The area covered by the lamella plates is typically 65 to 80 percent of the clarifier area required for a circular clarifier. Their design promotes laminar flow within the tubes, even when the water throughput is relatively high.

- ***Microfiltration for Precipitated Metals Removal.*** Chemical precipitation converts soluble metals into insoluble solids. One alternative to conventional clarifiers for removal of the insoluble solids is microfiltration.

Microfiltration has been observed at facilities manufacturing metal products and machinery and could potentially be used to remove solids from chemical precipitation effluents at iron and steel facilities (Reference 8-8). Microfiltration is a pressure-driven membrane process used to separate solution components based on molecular size and shape. Using an applied pressure difference across a membrane, solvent and small solute species pass through the membrane and are collected as permeate while larger compounds are retained by the membrane and are recovered as concentrate.

Microfiltration is used to remove materials ranging from 0.1 to 1.0-microns (e.g., colloidal particles, heavy metal particulates and their hydroxides). Numerous microfiltration membranes are isotropic in morphology and are typically made of homogeneous polymer material. Prefiltration is advisable for suspended solids loads above 200 mg/l. The transmembrane pressure required for microfiltration typically ranges between 3 to 50 pounds per square inch (psi) and is dependant on membrane pore size.

Microfiltration results in a concentrated suspended solid slurry that is typically discharged to dewatering equipment, such as a sludge thickener and filter press. The permeate can either be treated further for pH adjustment or be directly discharged, depending on local and state requirements. The microfiltration system includes a number of components such as pumps and feed vessels, piping or tubing, monitoring and control units for temperature, pressure and flow rate, process and cleaning tanks, and membranes. Membranes are specifically designed to handle various waste stream parameters, including temperature, pH, and chemical compatibility. Membranes can be purchased in several different configurations, including hollow fiber, tubular, flat plate, and spiral wound. The configuration selected for each application depends on the type of application. For example, tubular membranes are commonly used to separate suspended solids, whereas spiral wound membranes are used to separate oils from water. The tubular design microfiltration membranes are the least likely to foul with heavy suspended solids loadings and are easy to clean.

Polishing Technologies

Polishing technologies are the final treatment steps designed to remove residual, low concentrations of target pollutants from iron and steel wastewaters prior to discharge. Examples of polishing technologies include multimedia filters following clarification to remove small concentrations (less than 20 mg/L) of entrained suspended solids or carbon adsorption to remove trace concentrations of organic pollutants remaining in cokemaking wastewater following biological treatment. The following paragraphs describe each of these polishing technologies observed at iron and steel facilities.

- *Multimedia Filtration (mixed-media filtration).* Multimedia filtration, one of the oldest and most widely applied types of filtration for the removal of suspended solids from aqueous liquid streams, utilizes a bed of granular particles as the filter medium. Granular media filters are used to remove suspended solids from cokemaking wastewater following biological treatment, from high-rate recycle cooling water and blowdown water from blast furnace ironmaking, sintering, continuous casting, and hot forming operations. The bed may consist of one type of medium (e.g., sand) of same particle size, or multiple particle size. Different types of media (e.g., sand and gravel, sand and anthracite) with differing densities and different particle sizes, comprise the bed of a multimedia filter (Reference 8-9). Multimedia filters can be more efficient but more expensive and complex than single-media filters. The filter bed is contained within a basin or tank and is supported by an underdrain system, which allows the filtered liquid to be drawn off while retaining the filter medium in place. As suspended particle-laden water passes through the bed of the filter medium, particles are trapped on top of and within the bed. Once the pressure drop across the filter is large enough to impede flow, the filter is backwashed and the backwash water is typically sent to clarifiers or gravity thickeners.

- *Granular Activated Carbon.* Activated carbon adsorption has been observed as a polishing treatment step to remove residual concentrations of phenol and PAHs from cokemaking wastewater following biological treatment. It removes dissolved organic compounds from wastewater streams via adsorption. Activated carbon can also be used as a final treatment step to remove dioxins and furans from sinter plant wastewater or phenols from blast furnace ironmaking wastewater. Adsorption is a natural process by which molecules of a dissolved compound collect on and adhere to the surface of an adsorbent solid. Adsorption occurs when the attractive forces at the carbon surface overcome the attractive forces of the liquid. Activated carbon is a well-suited medium for this process due to its large internal surface area, high attraction to adsorbates (pollutants to be removed), and hydrophobic nature (i.e., water will not occupy bonding sites and interfere with the adsorption of pollutants). Pollutants in the wastewater bond to the activated carbon grains until all the surface bonding sites are occupied. When all bonding sites are occupied, the carbon is considered to be "spent." Spent carbon requires regeneration, which reduces adsorption capacity. After several regenerations, the carbon is disposed of.

  A granular carbon system generally consist of vessels in which the carbon is placed, forming a "filter" bed. Vessels are usually circular for pressure systems or rectangular for gravity flow systems. For wastewater treatment, activated carbon is packed into one or more filter beds or columns. Typical treatment systems consist of multiple filter beds in series. Wastewater flows

through the filter beds and is allowed to come in contact with all portions of the activated carbon. The activated carbon in the upper portion of the column is spent first (assuming operation is downflow mode), and progressively lower regions of the column are spent as the adsorption zone moves down the unit. When pollutant concentrations at the bottom of the column begin to increase above acceptable levels, the entire column is considered spent and must be replaced.

All vessels must be equipped with carbon removal and loading mechanisms to allow for the removal of spent carbon and the addition of new material. Vessels are backwashed periodically to remove the accumulated suspended solids in the filter bed. Surface wash and air scour systems can also be used as part of backwash cycle. The activated carbon systems may include carbon storage vessels and thermal regeneration facilities.

Solids Handling Technologies

Solids are generated from a number of the proposed treatment technologies including 1) biological treatment and cyanide precipitation of cokemaking wastewater, 2) clarifiers for treatment of high-rate recycle water in the ironmaking and steelmaking processes, including backwash from multimedia filters, and 3) chemical precipitation and multimedia filtration of high-rate recycle blowdown and steel finishing process waters for metals removal, including backwash from multimedia filters. Dilute sludges from each of these processes are often concentrated by gravity thickening prior to dewatering by a variety of presses and filters. Filter cake collected from the dewatering equipment can be further processed by sludge dryers to removal additional moisture. The following paragraphs describe the solids handling technologies that are used to reduce the volume of treatment sludges generated by iron and steel facilities.

- *Gravity Thickening.* Gravity thickening is a physical liquid-solid separation technology used to dewater wastewater treatment sludge. Sludge is fed from a primary settling tank or clarifier to a thickening tank, where gravity separates the supernatant from the sludge, increasing the sludge density. The supernatant is returned to the primary settling tank. The thickened sludge that collects on the bottom of the tank is pumped to additional dewatering equipment or contract hauled for disposal.

  Gravity thickeners are generally used in facilities where the sludge is to be further dewatered by a mechanical device, such as a filter press. Increasing the solids content in the thickener substantially reduces capital and operating costs of the subsequent dewatering device and also reduces the hauling cost. Typically, gravity thickeners achieve sludge with 8 to 10 percent solids by weight (Reference 8-17).

- *Rotary Vacuum Filtration of Sludge.* The rotary vacuum precoat filter consists of a perforated plate steel drum deck covered with a filter cloth. A

diatomaceous earth precoat is used to prevent small suspended particles from passing through the filter and into the center of the drum where filtrate is removed. A knife blade is used to shave filter cake from the surface of the diatomaceous earth precoat filter, preventing the filter cake from reaching a thickness that would not adhere to the filter. Rotary drum filters typically rotate between 0.25 and 6.5 revolutions per minute (RPMs), depending on the concentration of suspended solids in the wastewater (Reference 8-11). Filtrate that passes through the filter cake and diatomaceous earth precoat enters the center of the vacuum drum and is collected in horizontal pipes connected to a center drain shaft. Solids collected from the rotary vacuum filter can be recycled to sintering operations to recover iron.

- ***Pressure Filtration of Sludge.*** The plate-and-frame filter press is commonly used for sludge dewatering in the iron and steel industry. A filter press consists of a series of parallel plates pressed together by a hydraulic ram (older models may have a hand crank), with cavities between the plates. The filter press plates are covered with a filter cloth and are concave on each side to form cavities. At the start of a cycle, a hydraulic pump clamps the plates tightly together and a feed pump forces a sludge slurry into the cavities of the plates. The liquid (filtrate) escapes through the filter cloth and grooves molded into the plates and is transported by the pressure of the feed pump (typically around 100 psi) to a discharge port. The solids are retained by the cloth and remain in the cavities. This process continues until the cavities are packed with sludge solids. An air blow-down manifold is used on some units at the end of the filtration cycle to drain remaining liquid from the system, thereby improving sludge dryness and aiding in the release of the cake. The pressure is then released and the plates are separated.

  The sludge solids or cake is loosened from the cavities and falls into a hopper or drum. A plate filter press can produce a sludge cake with a dryness of approximately 25 to 40 percent solids for metal hydroxides precipitated with sodium hydroxide (caustic), and 35 to 60 percent solids for metal hydroxides precipitated with calcium hydroxide (lime). The solids content attained depends on the length of the drying cycle. Filter presses are available in a wide range of capacities (0.6 ft^3 to 20 ft^3). A typical operating cycle is from 4 to 8 hours, depending on the dewatering characteristics of the sludge. Units are usually sized based on one or two cycles per day (Reference 8-11).

- ***Belt Filtration for Sludge Dewatering.*** The belt pressure filter consists of two continuous belts set one above the other. Conditioned sludge is fed in between the two belts. Three process zones exist. First, the sludge passes through the drainage zone where dewatering is effected by the force of

gravity. Then, the sludge passes into the pressure zone where pressure is applied to the sludge by means of rollers in contact with the top belt. Finally, the sludge is passed to the shear zone where shear forces are used to bring about the final dewatering. The dewatered sludge is then removed by a scraper. Belt filtration can produce a sludge cake with a dryness of approximately 25 to 30 percent solids (Reference 8-18).

• ***Centrifugation of Sludge.*** A sludge dewatering device collects wet sludge in a cone-shaped drum. The drum is rotated to generate centrifugal forces to concentrate solids to the walls of the drum. These solids are continually removed from the centrifuge by an auger, screw conveyor, or similar device. Centrifugation dewaters sludges, reducing the volume and creating a semi-solid cake. Centrifugation of sludge can typically achieve a sludge of 20 to 35 percent solids (Reference 8-11).

• ***Sludge Drying.*** Wastewater treatment sludges are often hauled off site to disposal sites. The transportation and disposal costs depend mostly on the volume of sludge. Therefore, sludge dehydration equipment following dewatering can further reduce the volume of the sludge and the overall disposal cost. The solids content of the sludge dewatered on a filter press is usually in the range of 25 to 60 percent. Dehydration equipment can produce a waste material with a solids content of approximately 90 percent (Reference 8-11).

There are several design variations for sludge dehydration equipment. A commonly used type is a sludge drying unit that uses an auger or conveyor system to move a thin layer of sludge through a drying region and discharge it into a hopper. Various heat sources are used for sludge drying, including electric, electric infrared, steam, and gas. Some continuous units are designed such that the sludge cake discharge from a filter press drops into the feed hopper of the dehydration unit, making the overall dewatering process more automated. System capacities range from less than 1 ft^3/hr to more than 20 ft^3/hr of feed. Sludge dehydration equipment requires an air exhaust system due to the fumes generated during drying. Energy requirements depend mostly on the water content of the feed stock and the efficiency of a given unit.

8.2   **Development of Technology Options**

In developing the proposed regulation, EPA used a focused rulemaking approach, conducting several data gathering and analysis activities concurrently and assessing only a limited number of technology options. This is unlike the traditional approach where EPA conducts these efforts consecutively and considers a wider range of wastewater management and treatment technology options. This focused rulemaking approach is feasible for the Iron and Steel regulation because the Agency has acquired a good understanding of the industry, its associated pollutants, and the available control and treatment technologies from its prior rulemaking efforts. EPA evaluated responses to industry surveys, data collected from Agency site visits and sampling episodes, and technical literature to determine potential in-process and end-of-pipe treatment technologies to form the basis of the proposed regulation. Of these technologies, EPA developed options incorporating pollutant control technologies that demonstrate effective past or current use in the iron and steel industry, consistent effluent quality with a high degree of pollutant reduction for pollutants of concern (supported by analytical data), and minimal non-water quality environmental impacts. The Agency did not perform detailed analyses on pollution control technologies that, after preliminary analyses, were determined to require significant capital and operating and maintenance costs without substantial pollutant removals. Because of the focused rulemaking approach, generally only one option is presented for each subcategory.

Extensive stakeholder involvement was also an important element of the focused rulemaking process. EPA met with industry representatives, citizen and environmental groups, and other stakeholders at various stages of the rulemaking process to discuss the preferred technology options and to identify issues of concern. Input from stakeholders allowed EPA to refine its proposed technology options. Stakeholders generally supported the chosen options because they were in place and demonstrating satisfactory performance levels.

While EPA establishes effluent limitations guidelines and standards based on a particular set of in-process and end-of-pipe treatment technology options, EPA does not require a discharger to use these technologies. Rather, the technologies that may be used to treat wastewater are left entirely to the discretion of the individual treatment plant operator, as long as the numerical discharge limits are achieved, as required by Section §301(b) of the Clean Water Act.

8.2.1   **Technology Options by Subcategory**

To establish the proposed limitations and standards, EPA reviewed data corresponding to "state-of-the-art" pollution control technologies in the iron and steel industry. Below is a summary of the technology options for the proposed effluent limitations guidelines and standards in each subcategory. Tables 8-1 and 8-2 show the in-process and end-of-pipe treatment technologies, respectively, that are applicable to the subcategories. The tables also identify whether a technology was included in the development of technology options.

Non-Recovery Cokemaking

Non-recovery cokemaking manufactures metallurgical coke by indirectly heating (with combustible gases) high-grade bituminous coal in an enclosed oven chamber without oxygen. Volatile gases are immediately combusted within and around the oven to provide the heat required for coke production. Non-recovery cokemaking plants also maintain a slight negative pressure in the coke ovens at all times, thereby eliminating door, refractories, and charging lid leakages associated with by-product recovery ovens. Unlike by-product recovery cokemaking, no process wastewater is generated at non-recovery plants. Plant service water is used in coke quenching operations at non-recovery plants. However, runoff from quenching operations is collected and reused until evaporation. Accordingly, zero discharge of process wastewater pollutants was the only technology option considered for this segment.

Cokemaking (By-Product Cokemaking)

As with non-recovery cokemaking, by-product cokemaking manufactures coke by indirectly heating coal without oxygen; however, volatile gases are driven off and refined in a coal chemical plant to manufacture products such as clean coke oven gas, tar, sulfur, ammonium sulfate, and light oil. Waste ammonia liquor, wastewater generated from by-product recovery processes, along with wastewater from WAPCs on coal oven preheating and charging operations, are co-treated at an end-of-pipe wastewater treatment plant. Wastewater from WAPCs on pushing operations is typically blown down to a coke quench station, combined with plant service water or other sources, and used until evaporated on coke. Of the iron and steel subcategories, by-product recovery cokemaking comprises the widest range of treatment technologies used by the industry. Biological treatment, used by 13 of the 14 direct dischargers and 3 of the 8 indirect dischargers; is the most common treatment technology. One direct discharger uses physical-chemical treatment in lieu of biological treatment. Of the 16 sites using biological treatment, all but one uses ammonia distillation prior to biological treatment. All five indirect dischargers without biological treatment use an ammonia still. Other treatment technologies in use at mills in North America during 1997 include alkaline chlorination, cyanide precipitation, and sand filtration followed by granular activated carbon filtration. Table 8-3 lists the various wastewater treatment technologies reported by direct and indirect discharge by-product recovery cokemaking facilities in industry responses.

Figures 8-5 through 8-8 show the BAT technology options for the 14 direct discharging by-product recovery cokemaking facilities throughout the United States. Figures 8-9 through 8-12 show the PSES options for the eight indirect discharging by-product recovery cokemaking facilities. BAT-1 includes oil and tar removal, flow equalization prior to ammonia stripping, free and fixed ammonia stripping, indirect cooling, flow equalization before biological treatment, biological treatment, and sludge dewatering. BAT-2 equals BAT-1 with cyanide precipitation and sludge dewatering prior to biological treatment. BAT-3 equals BAT-1 with alkaline chlorination to remove residual cyanide and ammonia, following biological treatment. BAT-4 equals BAT-3 with both multimedia filtration and granular activated carbon after alkaline chlorination to remove any residual toxic organic compounds that may be present.

EPA evaluated four PSES options for the indirect discharging by-product recovery cokemaking facilities. For PSES, treatment is carried out to ensure that pollutants discharged by the industry do not "pass through" POTWs to waters of the United States or interfere with POTW operations or sludge disposal practices. PSES-1 includes tar removal, flow equalization, and free and fixed ammonia stripping. PSES-2 is equal to PSES-1 with cyanide precipitation, sludge dewatering, and multimedia filtration. PSES-3 is equivalent to BAT-1. PSES-4 is equivalent to BAT-3.

Ironmaking

The technology options evaluated for this subcategory represent treatment of wastewaters associated with blast furnace and sintering operations, whether treated individually or co-treated. All sites with sintering operations with dry air pollution controls reported zero discharge of process wastewater in industry survey responses. Accordingly, EPA used zero discharge based on dry air pollution controls as the only technology option for sintering operations with dry air pollution control. Industry survey responses indicated that all sites with both sintering operations with WAPCs and blast furnace operations on site co-treat wastewater. Table 8-4 lists the high-rate recycle equipment and wastewater treatment technologies used at 14 sites. (One site in the cost and loads analysis currently discharges to slag quench, as discussed in Section 9, and was not included in the count of 14 sites). According to industry survey responses, 9 of these sites operated dedicated blast furnace treatment systems, 3 operated combined sintering and blast furnace treatment systems, 1 site co-treated wastewaters from sintering, blast furnace, and other iron and steel manufacturing processes, and 1 site operated a dedicated sinter plant treatment system. Of the 14 sites with blast furnace ironmaking operations that discharge wastewater to surface water or a POTW, 12 sites had Clean Water Act Section 301(g) variances for ammonia and total phenol. Table 8-4 does not include the treatment technology used by five blast furnace ironmaking sites that achieve zero discharge through slag quenching and one blast furnace ironmaking site that achieves zero discharge through discharge to an evaporation pond.

Figures 8-13 and 8-14 present BAT and PSES technology options evaluated by the Agency, respectively. BAT-1 for blast furnace ironmaking and sintering consists of high-rate recycle using a clarifier for solids removal with sludge dewatering; a cooling tower to lower the water temperature to acceptable levels for reuse in blast furnace gas cleaning; blowdown treatment with chemical precipitation for metals removal, alkaline chlorination for removal of cyanide, ammonia, and phenol; and multimedia filtration as a polishing step.

EPA is proposing one PSES options for the indirect discharging blast furnace ironmaking and sintering facilities. The PSES-1 option is equivalent to BAT-1, but without alkaline chlorination and multimedia filtration.

Integrated Steelmaking

The technology options evaluated for this subcategory represent treatment of wastewaters associated with BOF steelmaking, vacuum degassing, and continuous casting operations at integrated steelmaking facilities, whether treated individually or co-treated. Industry survey responses indicate that co-treatment is a common practice, but depends largely on

proximity of manufacturing processes. All sites with ladle metallurgy operations reported zero discharge of process wastewater in industry survey responses. Accordingly, EPA used zero discharge as the only technology option for ladle metallurgy operations. Table 8-5 lists the high-rate recycle equipment and wastewater treatment technologies reported by the 20 integrated sites employing basic oxygen furnace steelmaking, vacuum degassing, and/or continuous casting and one non-integrated facility that operates a basic oxygen furnace.

Figure 8-15 presents the BAT and PSES technology options evaluated by the Agency. Wastewater from WAPCs for BOFs are treated in a high-volume classifier or equivalent primary solids removal device before discharge to a high-efficiency clarifier. Carbon dioxide injection prior to clarification can be used for wet-open combustion and wet-suppressed combustion BOF recycle systems to remove scale forming metal ions from wastewater before reuse. Vacuum degassing wastewater is typically treated by a clarifier and cooling tower before recirculation. Continuous casting wastewater from the spray water system is treated in a scale pit with oil skimming to recover mill scale and remove O&G, a roughing clarifier for coarse solids removal, filtered, and cooled before reuse. Blowdown from each of these high-rate recycle systems can be treated in a dedicated chemical precipitation system or co-treated. The PSES-1 option is equivalent to the BAT-1 option.

Integrated and Stand-Alone Hot Forming

Equivalent technology options were evaluated for each segment of this subcategory: Carbon and Alloy Steel and Stainless Steel. For both segments, high-rate recycle and treatment of wastewater from contact water systems used for scale removal, roll cooling, product cooling, flume flushing, and other miscellaneous sources (e.g., roll shops, basement sumps) is common. Thirty of 38 surveyed sites from both segments have high-rate recycle systems in place. Table 8-6 lists the high-rate recycle equipment and wastewater treatment technologies reported by 38 integrated and stand-alone hot forming sites.

Figure 8-16 presents the BAT and PSES technology options evaluated by the Agency for the Carbon and Alloy Steel and Stainless Steel Segments of this subcategory. BAT-1 includes high-rate recycle using a scale pit with oil skimming, a roughing clarifier with oil skimming, sludge dewatering, a multimedia filter for polishing, and a cooling tower to lower the water temperature to acceptable levels for reuse and treatment of blowdown with multimedia filtration. PSES-1 is identical to BAT-1.

Non-Integrated Steelmaking and Hot Forming

Equivalent technology options were evaluated for each segment of this subcategory: Carbon and Alloy Steel and Stainless Steel. For both segments, high-rate recycle and treatment of wastewater from vacuum degassing, continuous casting, and hot forming operations at non-integrated facilities are common. Forty four of 46 surveyed sites from both segments reported having high-rate recycle systems in place for these operations. All sites with electric arc furnaces (EAFs) and ladle metallurgy stations reported zero discharge of process wastewater in industry survey responses. Accordingly, EPA used zero discharge as the only technology option for EAF and ladle metallurgy operations. Table 8-7 lists the high-rate recycle

equipment and wastewater treatment technologies reported used by the 46 non-integrated steelmaking and hot forming sites.

Figure 8-17 shows the BAT and PSES options evaluated by the Agency for non-integrated steelmaking and hot forming sites. This figure applies for both stainless and carbon steel products. BAT-1 and PSES-1 for both segments include high-rate recycle of vacuum degassing, continuous casting, and hot forming operations. Continuous casting wastewater from the spray water system is treated in a scale pit with oil skimming to recover mill scale and remove O&G. Effluent from the continuous casting scale pit is combined with untreated vacuum degassing wastewater in a roughing clarifier for coarse solids removal. A portion of the clarifier effluent is recycled to the vacuum degassing process. The remainder of the clarifier effluent is filtered, cooled, and either recirculated to continuous casting or discharged. Wastewater from hot forming operations is treated in a separate scale pit with oil skimming to recover mill scale and remove O&G. Scale pit effluent is treated in a roughing clarifier prior to multimedia filtration and cooling. The Agency considered BAT-2 for stainless steel sites: BAT-1 plus metals precipitation for the blowdown stream. A portion of the cooling tower effluent is recirculated to hot forming, while the balance is discharged. Sludge from both casting and hot forming clarifiers is dewatered. The Agency realizes that many sites may be configured such that the combined treatment of the BAT and PSES model plants may not be possible. In such cases, separate treatment equipment for manufacturing processes, as required, equivalent to the combined treatment system would achieve model treatment system effluent quality. EPA considered these variables when costing sites for treatment systems, as discussed in Section 9.

Steel Finishing

Separate technology options for this subcategory were evaluated for two segments: Carbon and Alloy Steel and Stainless Steel. The Carbon and Alloy Steel Segment technology options treat wastewater from acid pickling (typically with hydrochloric or sulfuric acids) and associated annealing operations, cold forming, alkaline cleaning, hot coating, and electroplating operations. The Stainless Steel Segment technology options treat wastewater from salt bath and electrolytic sodium sulfate (ESS) descaling, acid pickling (typically with sulfuric, nitric, and nitric/hydrofluoric acids), annealing operations, cold forming, and alkaline cleaning. For both segments, sites used in-process and end-of-pipe wastewater treatment. For in-process wastewater treatment, sites used countercurrent rinsing, recycle of fume scrubber water, and reuse of acid (acid regeneration, purification, recycle, or recovery).

Table 8-8 lists the in-process and end-of-pipe wastewater treatment technologies reported by 86 water discharging carbon, alloy, and stainless steel finishing sites that provided survey responses. Figures 8-18 and 8-19 show the BAT and PSES technology options for the Carbon and Alloy Steel and Stainless Steel Segments, respectively. As presented in the figures, the technology options for both segments are identical, except that acid purification units have been incorporated into BAT-1 and PSES-1 for sites pickling stainless steel with sulfuric and nitric/hydrofluoric acid. Otherwise, both segments include the following in-process treatment technologies: countercurrent rinsing and recycling of fume scrubber water. End-of-pipe wastewater treatment for BAT-1 and PSES-1 for both segments consists of a diversion tank, oil removal for segregated oily wastes, flow equalization, hexavalent chromium reduction for

hexavalent-chromium-bearing streams, multiple-stage chemical precipitation for all waste streams, gravity clarification, and sludge dewatering.

Other Operations (Direct Reduced Ironmaking)

EPA evaluated BPT options for direct reduced ironmaking (DRI) because the Agency is setting limits for the first time for the conventional pollutants in this segment. The treatment technologies that serve as the basis for the development of the proposed BPT include high-rate recycle with solids removal using a classifier and clarifier, cooling, sludge dewatering, and treatment of blowdown with multimedia filtration. Both sites operating in 1997 reported using this high-rate recycle technology for wastewater generated from DRI WAPCs, with one site reporting the use of multimedia filtration as blowdown treatment (see Table 8-9). Figure 8-20 shows the BPT technology option for DRI.

Other Operations (Forging)

EPA evaluated BPT options for forging because the Agency is setting limits for the first time for the conventional pollutants in this segment. BPT for forging operations consists of oil/water separation and high-rate recycle. Table 8-9 lists the technology reported by sites to treat wastewater generated from forging contact water systems. Figure 8-21 shows the BPT technology option for forging.

Other Operations (Briquetting)

EPA evaluated BPT options for briquetting because the Agency is setting limits for the first time for the conventional pollutants in this segment. The four existing briquetting sites in the United States reported zero discharge of process wastewater. Accordingly, the Agency used zero discharge based on dry air pollution controls as the only technology option to develop the basis for BPT limitations and standards for briquetting operations.

8.3   References

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Table 8-1

Iron and Steel In-Process Technologies

Technology	Applicable Subcategories	Comments
High-rate recycle of wastewater	Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Other Operations	Has a significant impact on both the volume of water and the pollutant loadings discharged from a number of iron and steel operations. High-rate recycle is well demonstrated in each of the applicable subcategories. Included in the technology options.
Countercurrent cascade rinsing	Steel Finishing	Reduces the amount of water necessary for rinsing. Included in the technology options.
Fume scrubber recycle	Steel Finishing	Recycle system can significantly reduce the volume of water discharged from WAPC equipment. Included in the technology options.
Hydrochloric acid regeneration	Steel Finishing	Can reduce the amount of spent acid generated by the facility. Also reduces the amount of neutralization treatment chemicals needed and the mass of chlorides discharged. However, this process is energy-intensive and is only economically achievable at certain sites. Not included in the technology options.
Effluent-free pickling process with fluid bed hydrochloric acid regeneration	Steel Finishing	Would achieve zero discharge for hydrochloric acid pickling operations. However, this process is energy-intensive and was not included in the technology options. Also, the quantity of rinse and scrubber water that can be used to cool off-gases depends on the iron content of the pickle liquor, thereby limiting applicability.
Sulfuric acid recovery	Steel Finishing	Can reduce the amount of spent acid generated by the facility. Also reduces the amount of neutralization treatment chemicals needed and the mass of sulfates discharged. However, this process is energy-intensive and was not included in the technology options.
Acid purification	Steel Finishing	Can reduce the amount of spent acid generated by the facility. Also reduces the amount of neutralization treatment chemicals needed and the mass of anions such as nitrate, sulfate and fluoride discharged. Included in the technology options.
Nitric acid free pickling	Steel Finishing	The Agency is currently considering regulating nitrates/nitrites and is investigating the applicability of this technology. For proposal, acid purification was included in the technology options and this technology has not been included.
Effluent-free exhaust cleaning for stainless steel pickling	Steel Finishing	Would eliminate wastewater generated from scrubbing of exhaust gases from stainless steel pickling operations. Has significant capital and operating and maintenance costs as well as possible cross-media impacts. Is not included in the technology options.

Table 8-1 (Continued)

Technology	Applicable Subcategories	Comments
In-tank filtration to extend the life of concentrated baths	Steel Finishing	Not applicable at all sites and not included in the technology options.
Magnetic separation of fines in cold rolling solution	Steel Finishing	Not included in the technology options. Additional data would need to be collected to perform an evaluation.
Ion exchange	Steel Finishing	Would not be economically achievable at high flow rates and is therefore not applicable at all sites. Not included in the technology options.
Evaporation with condensate recovery	Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing	Energy-intensive and can have cross-media impacts. Not included in the technology options.
Best management practices/plant maintenance and good housekeeping practices	Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing	The benefits of these practices are not quantifiable. Not included in the technology options.

Table 8-2

Iron and Steel End-of-Pipe Treatment and Disposal Technologies

Technology	Applicable Subcategories	Comments
Flow Equalization		
Equalization	Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations	Included in the technology options.
Cooling Technologies		
Cooling towers	Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Other Operations	Included in the technology options.
Shell-and-tube heat exchangers	Cokemaking	Included in the technology options.
Coke Plant Treatment Technologies		
Tar removal	Cokemaking	Demonstrated in the cokemaking industry, improving the performance of the free and fixed ammonia still. Included in the options.
Ammonia steam stripping	Cokemaking	Applicable to wastewater containing high concentrations of ammonia. Well demonstrated in the cokemaking industry and included in the technology options.
Biological nitrification	Cokemaking	Applicable to wastewater with high concentrations of ammonia such as those found after steam stripping of waste ammonia liquor. Included in treatment options.
Denitrification	Cokemaking	Capital and operating costs are excessive for removal of nitrate. Not included in the options.

Table 8-2 (Continued)

Technology	Applicable Subcategories	Comments
Cyanide Treatment Technologies		
Cyanide precipitation	Cokemaking	Can remove cyanide from excess ammonia liquor. Demonstrated at cokemaking facilities and included in the technology options.
Alkaline chlorination	Cokemaking Ironmaking	Included in the technology options.
Cyanide oxidation by ozone	Cokemaking Ironmaking	The generation of ozone requires expensive equipment and safety controls. An equivalent technology (cyanide destruction through alkaline chlorination) was included in the technology options. Not included in the technology options.
Oil Wastewater Treatment Technologies		
Oil skimming	Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing	Effective for non-emulsified oils. Included in the technology options.
Chemical emulsion breaking followed by gravity oil/water separation	Steel Finishing	Included in the technology options.
API oil/water separator	Steel Finishing Other Operations	Included in the technology options.
Chemical emulsion breaking followed by dissolved air flotation	Steel Finishing	Energy-intensive relative to gravity flotation and therefore not included in the technology options
Ultrafiltration	Steel Finishing	May be cost-prohibitive at high flow rates. Not included in the technology options.

Table 8-2 (Continued)

Technology	Applicable Subcategories	Comments
Metals Treatment Technologies		
Chemical reduction of hexavalent chromium	Steel Finishing	Included in the technology options.
Chemical precipitation and gravity sedimentation	Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations	Included in the technology options.
Chemical precipitation and microfiltration	Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations	May be cost-prohibitive at high flow rates. Not included in the technology options.
Sludge Dewatering Technologies		
Gravity thickening	Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations	Included in the technology options.
Vacuum filtration	Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations	Included in the technology options.

Table 8-2 (Continued)

Technology	Applicable Subcategories	Comments
Sludge Dewatering Technologies (cont.)		
Pressure filtration	Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations	Included in the technology options.
Belt filtration	Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations	Demonstrated for dewatering of biological treatment sludge from cokemaking. Included in the options.
Centrifugation	Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations	Energy-intensive, and therefore not included in the technology options. Equivalent sludge dewatering technologies (gravity thickening and pressure filtration) are included in the technology options.
Sludge drying	Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations	Energy-intensive, and therefore not included in the technology options. May be cost-effective for some sites in certain situations.

Table 8-2 (Continued)

Technology	Applicable Subcategories	Comments
Polishing Technologies		
Multimedia filtration	Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations	Usually used in conjunction with another end-of-pipe technology (e.g., following chemical precipitation) or used to remove solids in the high-rate recycle treatment system. Included in the technology options. Also called mixed-media filtration.
Sand filtration	Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations	Usually used in conjunction with another end-of-pipe technology (e.g., following chemical precipitation). Similar to multimedia filtration, which has been included in the technology options. Not included in the technology options.
Granular activated carbon	Cokemaking Ironmaking	Included in the technology options.

Table 8-3

Wastewater Treatment Technologies Reported by Industry Survey Respondents for By-Product Recovery Cokemaking Sites

Treatment Technology	Number of By-Products Recovery Cokemaking Surveyed Sites Using the Technology	
	Direct Discharge (14 total sites)	Indirect Discharge (8 total sites)
Tar/oil removal	13	3
Flow equalization before ammonia still	12	4
Free and fixed ammonia still[a]	13	8
Cooling	10	1
Cyanide precipitation	1	2
Dephenolization	1	1
Alkaline chlorination[b]	0	0
Flow equalization before biological treatment or after ammonia still	13	5
Biological nitrification	13	3
Multimedia or sand filtration	4	1
Carbon adsorption	4	0
Sludge dewatering	12	2

[a]One indirect discharger operates an air stripping unit instead of an ammonia still.
[b] Although this technology is not practiced by industry survey respondents, the Agency is aware of one site in North America that practices alkaline chlorination.

Source: U.S. EPA, U.S. EPA Collection of 1997 Iron and Steel Industry Data (Detailed and Short Survey).

Table 8-4

High-Rate Recycle and Blowdown Treatment Technologies
Reported by Industry Survey Respondents for
Blast Furnace Ironmaking and Sintering Sites

Treatment Technology	Number of Blast Furnace Ironmaking and Sintering Surveyed Sites Using the Technology (14 total sites)[a]
High-Rate Recycle	
Clarifier	14
Cooling tower	11
Sludge dewatering	12
Blowdown Treatment	
Chemical precipitation	10
Alkaline chlorination	1
Multimedia filtration[b]	4
Granular activated carbon	1

[a] Includes three sites that co-treat blast furnace and sintering wastewater and one site that treats sintering wastewater only.
[b] Multimedia filtration of recycled flow or low-volume blowdown flow.
Note: Summary includes direct and indirect dischargers.

Source: U.S. EPA, U.S. EPA Collection of 1997 Iron and Steel Industry Data (Detailed and Short Survey).

Table 8-5

High-Rate Recycle and Blowdown Treatment Technologies Reported by Industry Survey Respondents for Integrated Steelmaking Sites

Treatment Technology	Number of Integrated Steelmaking Surveyed Sites Using the Technology (21 total sites)[a]
High-Rate Recycle	
Classifier[b]	12
Scale pit[c]	20
CO_2 injection	5
Clarifier	19
Cooling tower[d]	19
Sludge dewatering	13
Blowdown Treatment	
Chemical precipitation	7
Multimedia filtration[e]	18

[a]One site is a non-integrated mill with a BOF.
[b]Classifier used for BOF wastewater only except for one site that uses for continuous casting wastewater.
[c]Scale pit for continuous caster wastewater only.
[d]Cooling tower used for vacuum degassing and continuous caster wastewater.
[e]Multimedia filtration of recycled flow or low-volume blowdown flow.
Note: Summary includes direct and indirect dischargers and excludes zero discharge treatment systems.

Source: U.S. EPA, U.S. EPA Collection of 1997 Iron and Steel Industry Data (Detailed and Short Survey).

Table 8-6

**High-Rate Recycle and Blowdown Treatment Technologies
Reported by Industry Survey Respondents for
Integrated and Stand-Alone Hot Forming Sites**

Treatment Technology	Number of Integrated and Stand-Alone Hot Forming Surveyed Sites Using the Technology	
	Direct Discharge (32 total sites)	**Indirect Discharge (6 total sites)**
High-Rate Recycle		
Scale pit	25	3
Clarifier	15	4
Sludge dewatering	12	1
Cooling tower	20	4
Blowdown Treatment		
Chemical precipitation	2	0
Multimedia filtration[a]	10	1
Once-Through Treatment[b]		
Scale pit	7	1
Clarifier	0	0
Sludge dewatering	0	0
Multimedia filtration	0	0

[a]Multimedia filtration of recycled flow or low-volume blowdown flow.
[b]Once-through treatment applies to eight sites.

Source: U.S. EPA, U.S. EPA Collection of 1997 Iron and Steel Industry Data (Detailed and Short Survey).

Table 8-7

**High-Rate Recycle and Blowdown Treatment Technologies
Reported by Industry Survey Respondents for
Non-Integrated Steelmaking and Hot Forming Sites**

Treatment Technology	Number of Non-Integrated Steelmaking and Hot Forming Surveyed Sites Using the Technology		
	Direct Discharge (33 total sites)	Indirect Discharge (11 total sites)	Direct & Indirect Discharge (2 sites)
High-Rate Recycle			
Scale Pit with oil skimming	29	10	2
Clarifier	17	3	2
Cooling tower[a]	24	9	2
Blowdown Treatment			
Chemical precipitation	7	1	1
Multimedia filtration[b]	25	4	2
Once-Through Treatment[c]			
Scale pit	2	0	
Clarifier	0	0	
Cooling Tower	0	0	

[a]Cooling tower used for vacuum degassing and/or continuous casting wastewater.
[b]Multimedia filtration of recycled flow or low-volume blowdown flow.
[c]Once-through treatment only applies to two sites, both direct dischargers.

Source: U.S. EPA, U.S. EPA Collection of 1997 Iron and Steel Industry Data (Detailed and Short Survey).

Table 8-8

In-Process and End-of-Pipe Wastewater Treatment Technologies Reported by Industry Survey Respondents for Steel Finishing Sites

Treatment Technology	Number of Steel Finishing Sites Surveyed Using the Technology	
	Direct Discharge (57 total sites)	Indirect Discharge (32 total sites)
In-Process Treatment		
Countercurrent rinsing	14	10
Recycle of fume scrubber water	33	14
Acid purification and recycle[a]	7	5
End-of-Pipe Treatment		
Oil removal[b]	25	9
Flow equalization	34	19
Hexavalent chromium reduction[c]	23	5
Chemical precipitation	54	20
Gravity sedimentation/clarification	54	17
Sludge dewatering	49	18

[a]Applies to sites with sulfuric acid and nitric/hydrofluoric acid baths for stainless products.
[b]Oil removal technologies in place were primarily oil water separators and oil skimming; however, one site used ultrafiltration.
[c]Applies to sites with hexavalent-chromium-bearing wastewater.
Note: 47 sites reported the use of fume scrubbers.

Source: U.S. EPA, U.S. EPA Collection of 1997 Iron and Steel Industry Data (Detailed and Short Survey).

Table 8-9

**High-Rate Recycle Equipment and Blowdown Wastewater Treatment
Technologies Reported by Industry Survey Respondents for
Direct Reduced Ironmaking and Forging Sites**

Treatment Technology	Number of Sites Surveyed Using the Technology
DRI	(2 sites)
High-Rate Recycle	
Classifier and clarifier	2
Cooling Tower	2
Blowdown Treatment	
Multimedia Filtration	1
FORGING	(7 sites)
Oil Removal[a]	7

[a]Oil removal may be used as high-rate recycle or blowdown treatment.
Note: Summary includes direct and indirect dischargers.

Source: U.S. EPA, U.S. EPA Collection of 1997 Iron and Steel Industry Data (Detailed and Short Survey).